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Geological







A  
DESCRIPTIVE GUIDE  
TO THE  
MUSEUM OF PRACTICAL GEOLOGY,  
WITH NOTICES OF  
THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM,  
THE ROYAL SCHOOL OF MINES,  
AND  
THE MINING RECORD OFFICE.

---

BY  
ROBERT HUNT, F.R.S.,  
KEEPER OF MINING RECORDS,  
AND  
F. W. RUDLER,  
LATE ASSISTANT CURATOR.

*FOURTH EDITION.*  
REVISED AND PARTLY RE-WRITTEN.



LONDON:  
PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,  
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.  
FOR HER MAJESTY'S STATIONERY OFFICE.

1877.

*Price Sixpence.*



11036.

NOTICE.

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In addition to the detailed catalogues of special departments of the Museum of Practical Geology, this edition of "A Descriptive Guide to the Museum" has been prepared.

The first and second Editions were written by Mr. Robert Hunt, F.R.S., and the subsequent editions, of which this is the fourth, have been to a great extent revised and re-written by Mr. F. W. Rudler.

The steady sale of 15,000 copies of the various editions of these catalogues, is an evident sign of their utility to visitors.

ANDREW C. RAMSAY,  
Director General.

Museum of Practical Geology,  
November 1876.

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## INTRODUCTION.

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THE MUSEUM OF PRACTICAL GEOLOGY is intended to exhibit the rocks, minerals, and organic remains, illustrating the maps and sections of the GEOLOGICAL SURVEY OF THE UNITED KINGDOM: also to exemplify the applications of the Mineral productions of these Islands to purposes of use and ornament:—to show, in fact, the results which have been obtained from the efforts of thought and industry brought to bear upon the raw materials with which Nature has supplied us.

The collection, therefore, divides itself into two principal groups.

I. THE NATURAL MATERIALS—Geological and Mineralogical—which may be studied as to their lithological character, their geological order, or their mineralogical constitution.

II. THE ARTIFICIAL PRODUCTIONS, exhibiting the results of human labour aided by the discovery of science.

There are also three secondary, but important divisions.

THE MECHANICAL APPLIANCES, which are used in working the raw materials.

THE HISTORICAL SPECIMENS, which have been added with the view of preserving, in juxtaposition with modern manufactures, the productions of other ages and countries for purposes of comparison.

THE FOREIGN AND COLONIAL Minerals imported into this country in the natural state.

There are some other objects, valuable from their educational character, constituting a miscellaneous group, which cannot be brought within any of the above divisions. These are geological and mining models showing the various phenomena which occur in those districts which have been explored by man in his search for mineral treasure.

Such are the objects of the Museum of Practical Geology, which originated from a representation submitted in July 1835, by Sir Henry Thomas De la Beche, to the Chancellor of the Exchequer. The Geological Survey had recently been commenced in connection with the Ordnance Survey of the United Kingdom; and it was suggested that means therefore existed of collecting "Specimens of the Application of Geology to the useful purposes of Life." The importance of a Museum, which should fairly illustrate the mineral productions of the country, and show their commercial value, was at once recognized. The suggestion of Sir Henry De la Beche received the approval of the Government, and he was authorized to proceed in the development of his idea.

In 1837, Lord Duncannon, Chief Commissioner of Woods and Forests, allotted apartments in No. 6, Craig's Court, to receive the nucleus, around which has gathered the present extensive collection. THE MUSEUM OF ECONOMIC GEOLOGY, as it was first named (now the MUSEUM OF PRACTICAL GEOLOGY) was placed under the direction of its originator, and within a short period the collection became so valuable and important, that it was thought necessary to appoint a

curator, and accordingly in 1839, Mr. Richard Phillips, F.R.S., was chosen for the office. Advantage was taken of Mr. Phillips' abilities as a chemist, to unite analytical investigations with his duties as curator. A laboratory was attached to the establishment; analyses of minerals, rocks, and soils were made, and instruction was given, to a limited number of students, in chemistry and metallurgy. From this originated the ROYAL SCHOOL OF MINES (formerly called the GOVERNMENT SCHOOL OF MINES), united with this establishment, in which such branches of science are taught as have an especial bearing upon our mining and metallurgical industries. The office of curator and chemist was retained by Mr. Richard Phillips until his death, which occurred upon the day on which the present building was opened.

As the Geological Survey progressed, the Museum was rapidly extended. The original idea of a collection so practical in its character, and so peculiarly adapted to the wants of a great commercial and manufacturing community, being felt to be a correct and useful one, presents flowed in from persons interested in those particular branches of industry which it was intended to illustrate.

In August 1838, a representation was made to the Government by a Committee of the British Association for the Advancement of Science, to the effect "that with a view to prevent the loss of life and of property which will inevitably ensue from the want of accurate Mining Records, it is a matter of national importance that a depository should be established for the collection and preservation of such Mining Records of subterranean operations in collieries and other mining districts." The result of this was that an office was established, under the title of the MINING RECORD OFFICE, and Mr. T. B. Jordan was appointed the Keeper of Mining Records in 1839, which office he held until 1845, when he was succeeded by the author of this Descriptive Guide.

In 1845 the Geological was separated from the Ordnance Survey, and placed, with the Museum of Practical Geology, under the Department of Woods and Forests. The necessity for fitting accommodation became so pressing that, with as little delay as possible, the present building was erected by Mr. J. Pennethorne, for the Office of Woods and Works, the Chief Commissioner at that time being the Earl of Lincoln (the late Duke of Newcastle). It was opened to the public in May 1851, by His Royal Highness the late Prince Consort, and in November in the same year Sir Henry De la Beche delivered his inaugural discourse at the opening of the School of Mines.

The Geological Survey—now under the guidance of Professor Andrew Crombie Ramsay, LL.D., F.R.S., as Director-General—has, in its progress been constantly adding to the stores of the Museum of Practical Geology, and it is now especially rich in those illustrations which show us the progress of life upon this globe, and mark its great mutations. Its Palæontological collections, whether regarded as objects of scientific interest, or as guides to the searcher for mineral treasures, are of the highest value. The mineral groups, either in their earthy or the metalliferous divisions, have a large commercial interest, and must convey to all attentive minds an instructive lesson.

It is to guide the public in their examination of those specimens, —to inform them of their natural peculiarities,—and some of the methods by which they are rendered practically useful, that the present work has been undertaken. This volume must not be mistaken for a Catalogue of the Museum; it is simply a Descriptive

Guide to the various groups of specimens which it contains. Hence it is that, although sufficient indications are given of the position in which the examples described are to be found, a system of grouping the objects under general headings has, in most cases, been adopted as the easiest means of communicating the largest amount of information within a limited space.

As considerable interest must eventually attach itself to every circumstance connected with the first experiment of a popular educational character made by the British Government, it has been thought desirable to put on record some account of the opening of this Institution.

On Monday, May 14, 1851, the Museum of Practical Geology was formally opened by His Royal Highness the late Prince Consort, in the presence of a large circle of the leading members of the world of science, and of the aristocracy. The Prince Consort having taken the chair, on the principal floor, Sir Henry De la Beche, as Director of the establishment, approached His Royal Highness and read the following address:

" To His Royal Highness the PRINCE CONSORT, D.C.L.,  
" F.R.S., &c.

" May it please your Royal Highness,

" We, the officers of the Museum of Practical Geology, deeply sensible, in common with our fellow countrymen, of the earnest and increasing desire of your Royal Highness to patronize and aid all that may advance the happiness and promote the progress of our nation, and not only of this, but also of other lands, as is abundantly proved by the untiring exertions which have brought so vast a design as an Exhibition of Industry of all Nations to that successful issue which will make it memorable in the annals of our country, request permission to express our respectful thanks for this establishment having been considered one to be included among those which have public advantage and progress for their objects, and as such deemed worthy this day of the presence of your Royal Highness. The Museum of Practical Geology was founded, in 1835, in consequence of its having become evident, during the earlier progress of the Geological Survey of Great Britain, that numerous opportunities presented themselves, which it was not desirable to forego, for illustrating the applications of geology to the useful purposes of life. It was considered that collections should be made with that object, and be arranged with every reference to instruction, so that those interested might be enabled to judge how far our known mineral wealth might be rendered available for any undertaking they might be required to direct, or were anxious to promote, for the good or ornament of their country.

" As geological surveys necessarily include information which, if rightly interpreted, is of great value to agriculture, care was also taken to render the museum useful in that direction, so that, whether the districts examined were agricultural or mining, they should alike receive attention. To promote a knowledge of the properties of soils, as well as to effect an examination of the various ores of the metals, and of other mineral products of importance to the possessor of mineral property, the miner, the engineer, the architect, and of those interested in arts and manufactures generally, a laboratory in connection with the museum became necessary. The laboratory has frequently proved useful to the departments of the Government. We may point to the inquiry for the Admiralty into the coals of this country best suited for our steam navy, the third and final report on which has just been laid before the Parliament, as among the last, and probably not the least, important investigations undertaken for the Government at this establishment. Though much has been accomplished for our collections by the progress of the Geological Survey, much also has been effected by the kind consideration of the various classes of the public interested in our advance, and, in consequence, presents to a large amount have swollen the collections to their present state. Many of these

presents have been alike extensive and valuable, and we feel no little pride in including your Royal Highness among those who have aided us with donations, as well at a time when the museum was in its infancy, located in a comparatively obscure building, as now, when, in a more appropriate structure, the various objects for which it was established can be effectively carried out. The museum had been so far developed in 1840 that, in consequence of a representation of a committee of the Association for the Advancement of Science, the Government directed an Office of Mining Records to be attached to it; and it is hoped that thereby, as was stated by that committee, many of those great losses of life and of capital which have been sustained from want of such records may, to a great extent, be avoided. A valuable collection of such records has been already formed; and we have also, in this department, to acknowledge the aid which your Royal Highness has afforded us, as Lord Warden of the Stannaries, by permitting copies of the mining plans and sections of the Duchy of Cornwall to be taken for this office. It is but right, also to state, that from the mining interests generally we have experienced every encouragement, with regard to our mining records, so that we may hope, at no distant date, to have collected an amount of practical information on this head especially valuable as regards old workings and mines which have been abandoned.

"Though many years since, in 1839, the Government sanctioned lectures in connection with the museum on analytical chemistry, agricultural chemistry, metallurgy, mining and mineralogy, the want of proper accommodation has, until the present time, prevented their delivery. Now, however, that a theatre for them has been provided, it has been deemed expedient to extend these lectures, so as to embrace instruction of a character resembling that given in Foreign Schools of Mines, and which, while it should be adjusted to the wants of this country, should also have reference to the mineral wealth of the empire at large.

"Several memorials from important mining districts have been presented to the Government, to afford facilities at this establishment for instruction available for the mining interests, one of so much magnitude in this country; the value of the mineral products of Great Britain and Ireland being now estimated at 25,000,000<sup>l</sup>.\* per annum, the various products taken as nearly as possible in their first state. It has been further estimated by competent foreign writers that the annual value of the mineral substances raised in the British islands is equal to about four-ninths of that of all Europe, including these islands.

"To your Royal Highness it would be needless to point out the bearing of the Mining Schools of France, Saxony, Russia, and Austria upon the mineral resources of those countries, the useless expenditure they prevent, and the real productiveness they promote. To those whose duty it is to pass among our mining districts, it is often matter of regret to find many a powerful mind struggling with a want of knowledge of that which others have accomplished, or may be now doing. Great as the achievements of uninstructed men have sometimes been in such districts, they would have been still greater, and the instances would have been more multiplied, had better opportunities been afforded.

"While it is proposed to receive pupils by regular courses of study,—to teach by means of lectures,—experimental researches in the laboratory,—and also by the aid of the Geological Survey in the field, the collections of the museum will be gratuitously open to public view. Your Royal Highness will have seen, by inspection of these collections, that they are alike scientific and practical. We feel that in this we are not likely to have erred in the opinion of those who believe, as we do, that the greater the amount of science, the greater will be the amount of its application. In addressing your Royal Highness on this subject, we know that we are addressing a Prince who feels a deep interest in it, and who justly appreciates its general bearing.

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\* The value of the mineral produce of the United Kingdom, excluding building stones, amounted, in 1874, to 57,839,697<sup>l</sup>. sterling.

"That the honoured consort of our beloved Queen may long continue to exercise that beneficial influence which his enlarged views and exalted station command, is the earnest and sincere hope of the officers of this establishment."

Sir Henry de la Beche, having concluded reading the address, presented it to the Prince.

His Royal Highness acknowledged it in the following terms:—

"In thanking you for the address which you have just read to me, I would also express the sincere gratification with which I witness the opening,—in a form more likely to make it generally and practically useful,—of an institution the progress of which I have long watched with much interest, and the want of which has been long felt in this country. I rejoice in the proof thus afforded of the general and still increasing interest taken in scientific pursuits; while science herself, by the subdivision into the various and distinct fields of her study, aims daily more and more at the attainment of useful and practical results. In this view it is impossible to estimate too highly the advantages to be derived from an institution like this, intended to direct the researches of science and to apply their results to the development of the immense mineral riches granted by the bounty of Providence to our isles and their numerous colonial dependencies. It will always give me the greatest pleasure to hear of, and, as far as I am able, to contribute to, the continued success of the Museum of Practical Geology."

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# A DESCRIPTIVE GUIDE, &c.

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## THE BUILDING.

The edifice itself must be regarded as one of the illustrations of the main objects in view. It was designed by Mr. James Pennethorne, who, co-operating with Sir Henry De la Beche, endeavoured to make it, in all particulars, an illustration of the applications of Geology.

The Piccadilly front of the Museum is constructed of Anston (Yorkshire) Dolomite or magnesian limestone, of the same kind as that employed for the exterior of the new Houses of Parliament. The Jermyn Street front is composed partly of the same stone, and partly of Suffolk bricks.

The steps at the entrance are of the red granite of Peterhead, and at the doorway is a slab of slate from the Penrhyn quarries of North Wales. The pavement and steps leading into the hall are of Portland stone; the base of the sides of the vestibule is of Irish granite, the upper portion of polished Derbyshire alabaster; and the pilasters on either side at the heads of the steps from the vestibule are of grey Peterhead granite. As all these stones have their representatives in the hall, particulars respecting them will be found under their special heads.

## THE VESTIBULE AND HALL.

These are devoted to the exhibition of the building and ornamental stones of the United Kingdom, with such miscellaneous articles as could not be conveniently placed on any other floor.

## THE LECTURE THEATRES.

The large theatre is situated immediately north of, and is entered from, the Hall. It is constructed for seating 500 persons, but on many occasions, especially when lectures are delivered to the working men, considerably more than that number have been accommodated. In this theatre most of the lectures to the several classes of the ROYAL SCHOOL OF MINES are delivered; but a smaller room on the upper floor of the building is especially devoted to certain classes.

The session commences in October and terminates about the end of June. A prospectus and information may be obtained on application.

## THE LIBRARY.

Beyond the theatre in the Piccadilly front of the building is the Library of the institution, containing upwards of 25,000 volumes of books devoted to the sciences taught in the school. These are available for the use of the students of the SCHOOL OF MINES, and,

—upon special application, stating the object in view,—the books can be consulted by other inquirers. As most of the important periodicals relating to science published in this country, on the continent, and in America, are regularly received, and also the new publications bearing on the sciences taught, the number of books very rapidly increases.

#### THE PRINCIPAL FLOOR OF THE MUSEUM.

In this department will be found the collection of metalliferous minerals, with illustrations of metallurgy; the earthy minerals and their useful applications, exemplifications of the conditions under which metalliferous ores occur in nature. In fact all the principal objects which have a relation to Practical Geology will be found in this important division of the Museum.

#### THE MODEL ROOMS.

At the northern end of the principal floor are two rooms which, with a small supplementary room on the lower gallery, are devoted to mining and metallurgical models. Several, however, are distributed around the principal floor of the Museum.

A Descriptive Catalogue of the Models can be obtained in the building.

#### THE GALLERIES.

The lower and the upper galleries are devoted to scientific geology. The fossil collections will be found, commencing on the western side of the lower gallery, with the earliest forms of organization, and proceeding in an ascending order to the upper one. A Catalogue of the collection of Fossils, with an explanatory Introduction by Professor Huxley, is published. In the recesses of the upper gallery will be found a collection of British Rock specimens, of which a special catalogue is published.

THE GEOLOGICAL SURVEY, and THE MINING RECORD OFFICES will be found at the southern end of the upper gallery.

#### THE LABORATORIES.

The chemical studies of the students of the Royal School of Mines, under the charge of Dr. Frankland, are conducted at the Science Schools, South Kensington. The two Laboratories in the building in Jermyn Street, one on the basement, and the other at the northern end of the upper gallery, are devoted to Metallurgy under the direction of Dr. Percy.

Students of the School of Mines receive practical instruction in Biology under Professor Huxley, and in Physics under Dr. Guthrie, at the Laboratories at South Kensington.

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## THE COLLECTIONS.

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### THE HALL.

Although it is foreign to the general purpose of this guide-book to insert special catalogues of any of the collections exhibited, it has yet been considered desirable to introduce the following inventory of the objects in the Hall, since this department—unlike most other sections of the museum—is not provided with a catalogue of its own. In the arrangement of this inventory no system of classification has been attempted, but the convenience of the visitor has alone been consulted, and the objects have consequently been numbered in that order in which it is believed they will be found with the least possible difficulty. The numbers commence on the right-hand side of the steps on entrance; they are first carried round the walls, and are thence continued to the objects in the general area, passing from the western side along the northern end to the eastern side, and finally around the central pavement, terminating with No. 232, at the foot of the left-hand or western staircase.

Appended, in most cases, to each item in the inventory is a reference indicating the page of this guide-book at which a general description of the object under examination may be found; and it is hoped that with this system of reference no difficulty whatever will be experienced in immediately finding the information required respecting any object in this department.

#### INVENTORY of OBJECTS in the HALL.

No.

1. Column of porphyritic granite; Galway, Ireland (pp. 25, 27); supporting No. 2.
2. Bust of the late Sir R. I. Murchison, Bart., K.C.B., by H. Weekes, R.A. (p. 18). Bequeathed by Sir R. I. Murchison.
3. Column of red granite; Trowlesworthy, Cornwall (p. 26); supporting No. 4.
4. Statuette in terra-cotta inscribed "Mich. Rysbrack, 1753" (p. 150).
5. Column of marble; Matlock, Derbyshire (p. 30).
6. Large crystal of Quartz (p. 131); at foot of Case III.
7. Column of marble; Chudleigh, Devon (p. 32).
8. Column of marble; Babbacombe, Devon (p. 32).
9. Polished slab of pink granite; Aberdeenshire (p. 25).
10. Ornamental pedestal of granite; Fremator quarries, Devon (p. 26); supporting No. 11. Presented by Wagstaffe & Co.
11. Cast in plaster of Paris of a large Greek vase obtained at Naples by Sir Woodbine Parish, K.C.H., by whom it was presented (p. 43).
12. Large circular slab, or table-top, of dolomitic or magnesian conglomerate; Draycot, near Wells, Somersetshire (p. 33).
13. Column of marble; Lligwy, Anglesey (p. 33).
14. Slab of ammonite marble, consisting of a mass of *Ammonites Smithii*, Sby., and *A. planicostatus*, Sby., cemented by dark-coloured argillaceous carbonate of lime; Lower Lias of Marston, Somersetshire (p. 33).

15. Spirally-fluted column of Penrhyn slate (p. 35); supporting No. 16.
16. Bust of Charity in Watcombe terra-cotta; Devonshire. Presented by the Watcombe Terra-cotta Co., Limited (p. 154).
17. Polished block of Tisee marble; Hebrides (p. 34).
- 18, 19. Two polished slabs of Verd antique marble (p. 29).
20. Inlaid slab of steatite and serpentine; Lizard district, Cornwall (p. 29).
21. Slab of black Derbyshire marble, inlaid with "V. R." in red marble (p. 30).
22. Column of brecciated marble; Isle of Man (p. 33); supporting No. 23.
23. Bust in terra-cotta (p. 150).
- 24, 25, 26. three patent iron tubes, one of which is 13 ft. 4½ ins. in length, and 7 ins. in diameter. Manufactured by Messrs. Selby and Johns, Smethwick; and presented from the Great Exhibition, 1851, by Messrs. Bird & Co.
27. Inlaid table-top, containing 1,012 specimens of modern marbles (p. 30), agates (p. 133), alabasters (p. 34), &c. Collected by Professor Corsi, of Rome.
28. Inlaid table top, containing 1,012 specimens of ancient marbles (p. 30), agates (p. 133), alabasters (p. 34), &c. Collected among the ancient buildings of Italy, Greece, and Africa by Professor Corsi, of Rome, and referred to in his work "*Delle Pietre Antiche*."
29. Large mass of Websterite (p. 129); Newhaven, Sussex. Under Case I.
30. Bar of best Staffordshire iron, measuring 20 ft. 1 in. in length, and 7 ins. in diameter; and weighing 1 ton, 2 cwt., 3 qrs., 12 lbs. Rolled at the works of Messrs. J. Bagnall & Sons, West Bromwich, and presented from the Great Exhibition, 1851, by Messrs. Bird & Co. (p. 119).  
The screens which ornament the wall on this side are described at p. 16.
31. Large mass of purple copper ore, or Buntkupfererz, from near Disco, Greenland (p. 89). Presented by Sir W. Trevelyan, Bt., and Messrs. Robinson and Westenholz. Beneath Case III.
32. Boulder of hæmatite, or red-iron ore, from the base of the New Red Sandstone, Porlock, Somersetshire (p. 108). Presented by the late Mr. E. Rogers. Beneath Case III.
- 33 & 33A. Polished slabs of granite; Killiney, Ireland (p. 25).
34. Mass of red oxide of copper, from the Burra Burra mines, South Australia (p. 101). Presented by the directors. Beneath Case III.
35. Column of Derbyshire marble (p. 30).
36. Pilaster of red Peterhead granite (p. 25).
37. Column of black marble; Galway, Ireland (p. 33).
38. Slab of limestone, exhibiting ripple marks; from the Middle Purbeck beds, Durdlestone bay, Swanage (p. 38).
39. Terra-cotta figure of Galatea (p. 150), executed and presented by Messrs. Minton & Co.
40. Casts of weapons and armour in bronzed plaster of Paris, from Paris (p. 43). On the wall above.
41. Polished section of septarium from the Oxford clay, Weymouth (p. 45). Inlaid with sections of Ammonites and Belemnites (p. 176).

42. Column of marble; Nether Haddon, Derbyshire (p. 30).
43. Pilaster of serpentinous marble; Ballinahinch, Galway (p. 29).
44. Pilaster of marble; Babbacombe, Devon (p. 32).
45. Cube of calamine, or carbonate of zinc, from the Vieille Montagne Company's works, near Aix-la-Chapelle (p. 92). Presented by the Company, from the Great Exhibition, 1851. Beneath Case IX.
46. Large 6-inch bar of Staffordshire iron, rolled by Messrs. Bagnall and Sons, West Bromwich; and presented from the Great Exhibition, 1851, by Messrs. Bird & Co. (p. 119). Beneath Case IX.
47. Slab of fossiliferous Portland stone, from Tisbury, Wilts (p. 38). Beneath Case IX., western side.
48. Pilaster of Clonony marble; King's Co. Ireland (p. 33).
49. Portion of a large Sigillaria from the coal measures of South Staffordshire. Presented by Samuel Blackwell, Esq.
50. Large block of cannel coal from Haigh, near Wigan, Lancashire (p. 125). Presented, from the International Exhibition, 1862, by the Earl of Crawford and Balcarres.
51. Portions of large fossil plants, from the coal measures of Sydney, Cape Breton, British North America. Presented by the late Earl of Dundonald, G.C.B.
52. Specimen of *Syringodendron Boghalense*, from Boghall, near Cresswell, Northumberland. Figured in Sternberg's "Flora der Vorwelt," pl. XXXVII., fig. 5. Presented by Sir W. C. Trevelyan, Bt.
53. Portion of the trunk of a fossil tree from the dirt bed, Portland (p. 38). Presented by T. Foot, Esq.
54. Column of marble; Nether Haddon, Derbyshire (p. 30).
55. Silicified fossil wood, from the desert, near Cairo (p. 134). Presented by the late Dr. Buist.
- 56 & 57. Specimens of similar fossil wood, polished.
58. Column of marble; Sheldon, Derbyshire (p. 30); supporting No. 59.
59. Small column of volcanic ash from the Quantock Hills, Somersetshire. Presented by the Rt. Hon. Lord Taunton.
60. Polished marble slabs (p. 30).
61. Copy of the bust of the statue of Antinous as Bacchus, sculptured in Anston dolomite by Mr. C. H. Smith (p. 39). The stone presented by Mr. Grissell.
62. Polished circular slab of a septarium from the Oxford clay, Weymouth (p. 45).
63. Column of coralline marble; Tideswell, Derbyshire (p. 30). Supporting No. 64.
64. Plaster cast of bust of the late Professor J. B. Jukes, F.R.S. (p. 21), by Joseph Watkins.
65. Slab of alabaster from near Carrickmacross, Co. Monaghan, Ireland (p. 34). Presented by E. J. Shirley, Esq.
66. Octagonal slab with inlaid geometric design in varieties of marble (p. 30).
67. Polished slab of serpentine; Lizard district, Cornwall (p. 29).
68. Column of marble; Kenry, Limerick (p. 33); supporting No. .
69. Bust of William Smith LL.D., by M. Noble (p. 22).
70. Polished slab of stalagmitic aragonite, from Beni-souef, Egypt. Presented by the late Prince Consort.
71. Polished circular slab of stalagmitic aragonite, from Beni-souef, Egypt. Presented by the late Prince Consort.

72. Copy of the statue of the Farnese Hercules, sculptured in Portland stone by Mr. C. H. Smith (p. 38). The stone presented by Messrs. Stewards & Co.
73. Specimen of *Ammonites giganteus*, from the Portland beds (p. 38). Presented by G. Smith, Esq.
74. Polished table-slab of serpentinous marble; Ballinahinch, Galway (p. 29). Behind statue of Hercules.
75. Column of marble; Ipplepen, Devonshire (p. 30); supporting No. 76.
76. Bust of James Hutton, M.D., by Patric Park (p. 22).
77. Polished slab of rosewood marble; Derbyshire (p. 30).
78. Inlaid pavement of Keene's cement, copied from a Roman mosaic pavement, discovered in 1795, in a villa at Scampton, near Lincoln (p. 44).
79. Polished slab of encrinital marble; Derbyshire (p. 30).
80. Column of marble; Wirksworth, Derbyshire (p. 30).
81. Column of encrinital marble; Flagg, Derbyshire (p. 30). Supporting No. 82.
82. Tazza of red Derbyshire marble (p. 30).
83. Polished table-top of serpentine veined with steatite; Lizard Cornwall (p. 29).
84. Pedestal of red Peterhead granite (p. 25); supporting No. 85.
85. Copy of the Giustiniani Minerva, sculptured in Huddlestone dolomite by Mr. C. H. Smith (p. 39). The stone presented by Messrs. W. & J. Freeman.
86. Column of marble; Ashford, Derbyshire (p. 30).
87. Tazza of black Derbyshire marble (p. 30); inlaid with floral border in coloured marbles.
88. Column of alabaster; Chellaston, Derbyshire (p. 34).
89. Column of marble; Tideswell, Derbyshire (p. 30); supporting No. 90.
90. Cube of serpentine; Portsoy, Banffshire (p. 30). Presented by the Earl of Seafield. Supporting No. 91.
91. Obelisk of Portsoy Serpentine (p. 30).
92. Column of dark green serpentine from the Lizard, Cornwall, (p. 29); supporting No. 93.
93. Font in red and green varieties of Cornish Serpentine (p. 29).
94. Column of grey granite; Aberdeen (p. 25); supporting No. 95.
95. Copy of a bust of Bubastis in greenstone, from Llanwnda, Fishguard, Pembrokeshire; by Mr. C. H. Smith (p. 29).\*
96. Portion of a tessellated pavement, by Messrs. Wyatt, Parker, & Co. (p. 46).
97. Portion of an inlaid table-top of Derbyshire and Staffordshire marbles, made and presented by the late Mr. Milne, Ashford, Derbyshire (p. 31).
98. Column of marble; Allport, Derbyshire (p. 30).
99. Pilaster of encrinital marble; Ricklow Dale, Derbyshire (p. 30).
100. Column of Clonony marble; King's Co., Ireland (p. 33).
- 101 & 102. Polished slabs of stalagmitic carbonate of lime; Suisan Bay, California. Presented by E. Seyd, Esq.

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\* Alterations which are now in progress will probably necessitate slight changes in the position of several of the following objects.

103. Large mass of crystallized quartz (p. 131), coating galena (p. 107), and fluor spar (p. 131). From Weardale, Durham. Presented by W. B. Beaumont, Esq., M.P.
104. Coloured sketch on ground of Benson and Logan's metallic cement (p. 45). On wall above.
105. Cornice of grey granite, ornamented in intaglio and gilt.
106. Table with inlaid top of Devonshire marbles (p. 32).
107. Table with inlaid top of Derbyshire and Staffordshire marbles (p. 31). Worked by the late Mr. Milnes and Mr. Redfern.
108. Column of marble; Allport, Derbyshire (p. 30).
109. Pilaster of Ipplepen marble; Devon (p. 32).
110. Column of marble; Allport, Derbyshire (p. 30).
111. Polished slab of red Peterhead granite (p. 25).
112. Polished slab of grey granite; Aberdeen (p. 25).
113. Portion of a vein of auriferous or gold-bearing quartz, from the Grass Valley, Nevada county, California (p. 49). Presented by F. Catherwood, Esq.
114. Stereo-chromic painting, by Echter, of Munich (p. 45). On wall above.
115. Column of marble; Wirksworth, Derbyshire (p. 30).
116. Pilaster of serpentinous marble; Ballinahinch, Galway (p. 29).
117. Column of marble; Miller's Dale, Derbyshire (p. 30).
118. Polished slab of serpentinous marble; Ballinahinch, Galway (p. 29).
119. Pedestal of red Peterhead granite (p. 25); supporting No. 120.
120. Cast in plaster of Paris of the Apollo Belvedere (p. 43).
121. Polished slab of ennerital marble; Derbyshire (p. 30).
122. Column of alabaster; Chellaston, Derbyshire (p. 34).
123. Specimens of Penmaen-mawr stone; Caernarvonshire (p. 29). Beneath Case VII.
124. Mass of copper glance (p. 80), with iron pyrites (p. 108), and quartz (p. 131); from Tomnadashan copper mine, Loch Tay, Perthshire. Presented by the late Marquis of Breadalbane. Beneath Case VII.
125. Pilaster of red Peterhead granite; Aberdeenshire (p. 25).
126. Section of a septarium (p. 45). Under Case VI.
127. Polished slab of Devonshire marble (p. 32).
128. Polished slab of Derbyshire marble (p. 30).
129. Polished slab of dolomitic conglomerate; Coity, Glamorganshire (p. 33).

(Nos. 127, 128, and 129 are beneath Case V.)

130. Block of Jasper; from Trutham, Cornwall (p. 133). Presented by Montague Parker, Esq.
131. Polished slab of Devonshire marble (p. 32).
132. Polished slab of Plymouth marble (p. 32).
133. Frame containing eight slabs of Irish marble (p. 33). Presented by Messrs. Manderson, of Dublin.

(Nos. 131, 132, and 133 are beneath Case IV.)

N.B.—The southern end beneath the window is occupied by a collection of slates, described at p. 34.

134. Polished slab of porphyritic granite; Cornwall (p. 26).
- 135 & 135A. Polished slabs of elvan; Withiel, Cornwall (p. 28).
136. Polished slab of schorl rock; Roche, Cornwall.

137. Circular inlaid table-top of different varieties of Cornish serpentine (p. 29). On wall above.
138. Inlaid slab of pieces of agate (p. 133), jasper (p. 133), porphyry (p. 27). &c., found as pebbles on the beach at Aberystwith, Cardiganshire. On wall above.
139. Column of Plymouth marble (p. 32).
140. Polished slab of marble; Kitley Park, Yealmpton, Devon (p. 32).
141. Column of Plymouth marble (p. 32).
142. Column of marble; Stony Middleton, Derbyshire (p. 30).
143. Slab of shelly marble, from the Middle Peak, Derbyshire (p. 30).
144. Polished slab of Devonshire marble (p. 32).
145. Column of black marble; Moelfra, Anglesey (p. 33).
146. Column of marble; Wetton, Staffordshire (p. 31); supporting No. 147.
147. Statuette of Bailey's Flora, in Coade's terra-cotta (p. 150).
148. Pedestal of grey granite; Carnsue, Cornwall; with base of porphyritic granite, from Lamorna Cove, Land's End (p. 26); supporting No. 150.
149. Tazza of red serpentine, the shaft entwined by a dolphin of green steatitic serpentine; both from the Lizard, Cornwall (p. 29). Worked by Mr. Pearce, of Truro.
150. Column of grey schorlaceous porphyry, from Lanlivery. Cornwall (p. 27); supporting No. 152.
151. Cube of serpentine; Portsoy, Banffshire (p. 30). Presented by the Earl of Seafield. Supporting No. 153.
152. Tazza of red Aberdeen granite (p. 25).
153. Large pedestal and tazza of red Peterhead granite (p. 25). Worked, with many of the other Scotch granites, by Messrs. McDonald and Leslie, Aberdeen.
154. Column of schorlaceous porphyry (Luxullianite), from Luxullian, Cornwall (p. 28); supporting No. 155.
155. Vase of Derbyshire fluor spar ("Blue John,") one of the largest and finest examples known, having been executed for a royal personage at a cost of nearly 100*l.* (p. 63).
156. Pedestal of steatitic serpentine, with base of red and green serpentine, both from the Lizard, Cornwall (p. 29); supporting No. 157.
157. Cube of granite; Portsoy, Banffshire (p. 25). Presented by the Earl of Seafield. Supporting No. 158.
158. Tazza of Cornish serpentine (p. 29).

*(We here cross to the northern end.)*

159. Pedestal of encrinital marble from Dent, Yorkshire (p. 31), on plinth of granite, from Shap, Cumberland (p. 27); supporting No. 160.
160. Bust of the late Professor Sedgwick, by T. Woolner (p. 22). Presented by a Lady.
161. Pedestal of black marble; Castleton, Isle of Man (p. 33), with base of grey granite, from South Barrule, Isle of Man (p. 27); supporting No. 162.
162. Bust of the late Professor E. Forbes, by J. C. Lough (p. 20).
163. Copy of the Dying Gladiator, in Parian cement (p. 44); the base coloured in imitation of marble. Executed by Mr. Belman, the patentee.

164. Pedestal of grey granite ; Meldon, Devon (p. 26) ; supporting No. 165.
165. Model of an ancient cross in black slate (p. 34).
166. Pedestal of grey granite, from Constantine, Cornwall (p. 26) ; with base of schorlaceous porphyry from Luxullian (p. 28) ; supporting No. 167.
167. Tazza of black Derbyshire marble (p. 30).
168. Large block of apatite, or phosphate of lime (p. 48), with mica (p. 137) ; from North Burgess Mine, Perth, Ontario, Canada West. Presented by Messrs. Pickford, Winkfield, & Co.
169. Large mass of Phosphorite, containing 79 per cent. of phosphate of lime (p. 131), from Staffell, near Limburg, on the Lahn. Presented by Messrs. John Taylor & Sons.
170. Large pedestal and tazza of alabaster ; from Fauld, Staffordshire (p. 34). Worked by Messrs. Hall, of Derby.
171. Pedestal of grey granite ; Trewoon, Cornwall (p. 26).
172. Pedestal of grey porphyritic granite ; Lamorna Cove, Cornwall (p. 26) ; with base of schorlaceous porphyry, from Luxullian (p. 28) ; supporting No. 173.
173. Tazza of Derbyshire rosewood marble (p. 30).
174. Mass of red oxide of copper, coated with malachite ; from the mines of the Great Northern Copper Mining Company of South Australia (p. 48). Presented by the Hon. J. Baker.
175. Large mass of native copper ; from the mine at the Ghostcroft, Mullion, Cornwall (p. 47). Presented by the Adventurers of the Trenance mines.
176. Several portions of six-sided prisms of basalt, from the Giant's Causeway, Ireland (p. 47).
177. Fluted column of alabaster, from Fauld, Staffordshire (p. 34) ; with foot of Derbyshire marble (p. 30) ; supporting No. 178.
178. Large tazza of serpentinous marble ; Ballinahinch, Galway (p. 29).
179. Portion of a rich lead vein ; from the Grassington mines, near Skipton, Yorkshire (p. 48). Presented by the Duke of Devonshire.
180. Pedestal of granite ; Lee Moor, near Plympton, Devon (p. 26).
181. Pedestal of serpentine ; Lizard, Cornwall (p. 29).
182. Column of serpentinous marble ; Ballinahinch, Galway (p. 29) ; supporting No. 183.
183. Tazza of coralline marble ; Matlock, Derbyshire (p. 30).
184. Column of red marble ; Cork, Ireland (p. 33).
185. Specimens of black Derbyshire marble, arranged in a columnar series, to illustrate the method of turning and polishing (p. 30). Presented, from the Great Exhibition, 1851, by Messrs. Hall, Derby. Mounted on base of Cornish serpentine.
186. Column of Clonony marble ; King's County, Ireland (p. 33).
187. Column of marble ; Michelstown, Cork (p. 33).
188. Series of specimens of Derbyshire alabaster, arranged similarly to No. 185 (p. 34). Presented by Messrs. Hall, Derby. Mounted on base of Cornish serpentine.
189. Tazza of coralline marble ; Devonshire (p. 32).
190. Column of granite ; Hay Tor, Devon (p. 26) ; supporting No. 191.

191. Tazza of Cornish serpentine (p. 29).
192. Column of porphyritic granite: Blackenstone, Devon (p. 26); supporting No. 193.
193. Tazza of red encrinital marble; Derbyshire; with black marble base (p. 30).
194. Column of black Galway marble (p. 33); supporting No. 194.
195. Obelisk of Cornish serpentine (p. 29).
196. Pedestal of serpentinous marble; Rhoscolyn, Anglesey (p. 29); supporting No. 197. Presented by the Hon. Owen Stanley, M.P.
197. Model in black Derbyshire marble (p. 30) of the Luxor obelisk now erected in Paris.
198. Column of marble; Babbacombe, Devon (p. 32); supporting No. 199.
199. Tazza of dolomitic conglomerate; Coity, Glamorganshire (p. 33); with base of black marble.
200. Column of encrinital marble; Matlock Bath, Derbyshire (p. 30); supporting No. 201.
201. Tazza of marble; Wetton, Staffordshire; with black marble base (p. 31).
202. Column of grey granite; Cragnair, Kirkcudbrightshire (p. 25); supporting No. 203.
203. Tazza of black Derbyshire marble (p. 30).
204. Column of porphyritic granite; Shap, N. Westmoreland, (p. 27); supporting No. 205.
205. Tazza of shelly Derbyshire marble, with black marble base (p. 30).
206. Column of marble; Wetton, Staffordshire (p. 31); supporting No. 207.
207. Tazza of Derbyshire rosewood marble, with black marble base (p. 30).
208. Column of serpentinous marble; Ballinahinch, Galway (p. 29); supporting No. 209.
209. Amphora in Cornish serpentine (p. 29).
210. Column of red Peterhead granite (p. 25.); supporting No. 211.
211. Bust of Her most gracious Majesty the Queen (p. 17).
212. Column of red Peterhead granite (p. 25); supporting No. 213.
213. Bust of H.R.H. the late Prince Consort (p. 17).
214. Column of marble; One Ash, Derbyshire (p. 30); supporting No. 215.
215. Tazza in Cornish serpentine; a lizard, in a green variety of the stone, entwined around shaft of red serpentine (p. 29).
216. Pedestal of grey granite; Halvasso, Cornwall (p. 26); supporting No. 217.
217. Bust of the late G. B. Greenough, F.R.S. By N. Bernard (p. 19).
218. Pedestal of serpentinous marble; Ballinahinch, Galway (p. 29); supporting No. 219.
219. Bust of the late Sir H. T. De la Beche, C.B. By E. C. Papworth, Sen. (p. 19).
220. Column of serpentine; Lizard, Cornwall (p. 29); supporting No. 221.
221. Vase of Derbyshire fluor spar (p. 63); on black marble pedestal.

222. Column of marble; Bonsall, Derbyshire (p. 30); supporting No. 223.
223. Vase of Cornish serpentine (p. 29).
224. Slab of serpentinous marble; Rhoscolyn, Anglesey (p. 29). Presented by J. Haywood, Esq.
225. Pedestal of Cornish serpentine (p. 29); supporting No. 226.
226. Bust of Sir James Hall. By Patric Park (p. 23).
227. Pedestal of grey porphyritic granite; Cheesewring, Cornwall (p. 26); supporting No. 228.
228. Bust of Professor J. Playfair. By M. Noble (p. 23).
229. Column of rosewood marble; Ashford, Derbyshire (p. 30); supporting No. 230.
230. Tazza of black Derbyshire marble (p. 30).
231. Column of red granite; Ross of Mull, Argyleshire (p. 25); supporting No. 232.
232. Bust of the late Dr. Buckland, by H. Weekes, A.R.A. (p. 24). (At foot of western staircase.)

In addition to the objects described in the foregoing catalogue, there will be found in this portion of the building several groups of smaller specimens which are arranged, for convenience, in a series of table-cases distributed around the Hall. Of these cases Nos. I., II., and III., in the eastern embayment, contain polished cubes of British ornamental stones, descriptions of which will be found under the following general headings, viz.: Marble (p. 30); Granite (p. 24); Elvan (p. 28); and Serpentine (p. 29). On the opposite side of the Hall, in the western embayment, are cases Nos. IV., V., VI., and VII., containing samples of our British building stones. These specimens are chiefly those which were collected by the Commissioners appointed in 1838 to select the most durable material for the construction of the Houses of Parliament. The physical and chemical properties of the stones were determined by the late Professors Daniell and Wheatstone, the other members of the Commission being Sir Charles Barry, Sir Henry De la Beche, Mr. William Smith, and Mr. Charles H. Smith. The specimens submitted to the Commissioners, and on which they reported (*Report of Building Stone Commission, 15th July 1839*), were, by the order of the Lords of the Treasury, placed in this Museum, and the collection has since been augmented, partly by private donations and partly by contributions from the Geological Survey. For a description of the Sandstones, see p. 36; of the Limestones, p. 37; of the Dolomites, p. 39; and of the Granites and Elvans, p. 24.

Case VIII., on the western side, near the statue of the Apollo Belvedere, is devoted to examples of hard stones used for the purposes of grinding and polishing (p. 40). On the eastern side, near the large alabaster tazza, stands Case IX., containing an interesting collection, intended to illustrate the preparation and uses of plaster of Paris (p. 43), whilst the adjacent case, No. X., is occupied by samples of crucibles and melting pots, noticed at p. 46.

The wall-space on the eastern side of the Hall is decorated with British ornamental stones, commencing with a screen extending from the southern end to pilaster No. 36. In this screen, which is from the design of Mr. Charles F. Reeks, architect, the central panels are of Ballinahinch serpentinous marble, surrounded by grey Derbyshire marble, with running borders of guilloche and fretwork, the former of red Staffordshire marble and Derbyshire anhydrite, the latter of similar red marble and Derbyshire stalagmite. The

pilasters and architrave are of Lizard serpentine, whilst the base is of russet and bird's-eye marble from Derbyshire.

The screen between pilasters Nos. 36 and 44 exhibits a large central panel of marble from the Mumbles, Swansea, with smaller panels of Ipplepen marble, Devon; while the cornice is of Lizard serpentine, and the remainder of Derbyshire marbles.

In the space between pilasters Nos. 43 and 44 the circular centre is of Derbyshire rosewood marble, and the remaining panels of ennerinital, coralline, and other varieties of Derbyshire marble, whilst the ground in which the whole is inlaid is of Fauld alabaster, and the base of reddish syenitic granite from Mount Sorrel, Leicestershire (p. 27).

Scotch granites and marbles occupy the wall-space between pilasters Nos. 44 and 48. On the base of grey granite from Kenmay (Aberdeenshire) rests a moulding of red Corrennie granite, above which is a dado of grey granite from Cairngall, near Peterhead, surmounted by a cornice of pink granite from the Isle of Mull. In the upper part the ground is of red granite from the Stirling hill quarries, near Peterhead, whilst the central circular panel is of Strathdon marble (Aberdeenshire), and on each side of this is a panel of hornblendic porphyry from Mayon, near Huntly, Aberdeenshire. The remaining panels, which in most cases correspond on opposite sides, are, commencing from below, of Kingswell porphyry (Aberdeenshire); Glen Tilt marble (Perthshire); Sutherlandshire marble on the left hand, and Portsoy serpentine on the right; Tisce marble, Hebrides; and Rubislaw granite, Aberdeenshire.

The tessellated pavement in the centre of the Hall (p. 46) is surrounded by slabs of grey Aberdeen granite, and these again by slabs of red Peterhead granite, the whole being bordered by a guilloche in Minton's encaustic tiles, formed of compressed coloured clays. Similar tiles form a pavement at the top of the steps leading from the vestibule, and again on the north of the tessellated pavement around the statue of Hercules. The remainder of the pavement is of Portland stone (p. 38), as also are the columns supporting the roof.

While examining the contents of the Hall it should be borne in mind that the object of this section of the Museum is almost purely technological, its main purpose being the illustration of the applicability of the rocks of the United Kingdom to purposes of architecture and ornament. Hence the geological student who wishes to study the physical characters of our rocks rather than their industrial uses must be referred to the series of British rock specimens in the upper gallery and to the mineral collection on the principal floor, detailed catalogues of both of which have been published.

#### BUSTS.

HER MOST GRACIOUS MAJESTY THE QUEEN.

*Executed by Francis, 1850. No. 211.*

H.R.H. THE LATE PRINCE CONSORT.

*Executed by Francis, 1843. No. 213.*

These being cast in zinc, are subsequently bronzed, and are examples of the application of an inexpensive material in the production of works of art.

The busts of eminent men who have advanced the science of Geology form appropriate and interesting features in this Hall. To increase their interest to the visitor the following brief biographical

notices are introduced. The busts are described in the order in which they will be most readily found by the visitor, who on entrance turns to the right and proceeds around the tessellated pavement in the central area.

SIR RODERICK I. MURCHISON, BART., K.C.B.—*An original bust by H. Weekes, R.A., 1871. Bequeathed by Sir R. I. Murchison. No. 2.*

SIR RODERICK IMPEY MURCHISON, who succeeded Sir Henry De la Beche as Director of this Institution, was born at Tarradale, in Ross-shire, on February 19, 1792. Intended for the army, he was educated at the Royal Military College at Great Marlow, and in 1807 he obtained a commission in the 36th Foot. During his military life he saw active service in the Peninsula, and was present at the battle of Vimiera and the retreat on Corunna. On the conclusion of the war he married the daughter of General Hugonin, and soon afterwards quitted the army, though it was not until 10 years later that his attention was turned, by Sir Humphrey Davy's influence, to scientific pursuits. His first practical lessons in geology were received from Dr. Buckland, whose enthusiasm incited Murchison to enter the field as an original observer, and thus determined his future career. In 1825 he contributed his first paper to the Geological Society, of which he was henceforth one of the most prominent members. Murchison's great work, the work with which his name will always be identified, was that of determining the succession of the older rocks, which had previously received but little attention from geological observers. This task he commenced in 1831 by working on the old rocks of Wales in conjunction with Professor Sedgwick, the two proceeding, however, from different base-lines. Sedgwick's labours lay among the disturbed rocks of North Wales, where he established his "Cambrian System;" Murchison's among the rocks of South Wales, where he laid the foundation of his "Silurian System." The famous work bearing as its title "The Silurian System" was published in 1836. Soon afterwards Murchison's attention was turned to the geology of Russia, and in 1840 he visited a part of the empire in company with the French geologist, M. De Verneuil. The following year he returned and made a more extended survey, aided by Count Keyserling, and encouraged by the Emperor Nicholas, but it was not until 1854 that he published his fine work, the "Geology of Russia and the Ural Mountains." In the same year he brought out, under the title of "Siluria," a large volume giving a general description of the older rocks, or a summary of palæozoic geology.

At an early period of Murchison's geological career he had shown, in conjunction with Sedgwick, that the slaty rocks of Devonshire are approximately of the same age as the red sandstones of Herefordshire, and thus established the "Devonian System." The formation of the "Permian System" was suggested at a later date by his travels through the old kingdom of Perm, in Russia, where he found a large development of rocks of this geological age. In 1846 Mr. Murchison received the honour of knighthood, and on Sir H. De la Beche's death, in 1855, he was appointed Director of this Museum and of the Geological Survey of the United Kingdom. He was one of the original founders of the British Association, and presided over its meeting at Southampton in 1846. Geographical science shared his attention with geology, and from 1844 to the time of his death he was almost perpetual President of the Royal Geographical Society. Through his influence a chair of Geology and Mineralogy was esta-

blished in the University of Edinburgh in 1871, and towards the endowment of this chair he contributed 6,000*l*. The "Murchison Professorship," as he wished it to be called, is held by his biographer, Mr. Archibald Geikie, Director of the Geological Survey of Scotland. Sir Roderick died on October 22, 1871, and was succeeded by Professor A. C. Ramsay as Director-General of the Geological Survey and of the Museum of Practical Geology.

GEORGE BELLAS GREENOUGH, F.R.S.—*An original bust by Neville Burnard, 1859, presented by the late Miss E. M. Smedley. No. 217.*

GEORGE BELLAS GREENOUGH, the founder of the Geological Society, was born in 1778, and died at Naples in 1855. Intending to follow the legal profession, Mr. Greenough, after studying at Cambridge, proceeded to the University of Göttingen, where the attractions of Blumenbach's lectures on natural history induced him to abandon the law, and devote his energies to the pursuit of natural science. With this view he subsequently studied at the mining school of Freiberg, under the distinguished Werner, whose views he warmly espoused during the unhappy controversy between the Neptunists and Vulcanists. In the formation of the Geological Society of London, Mr. Greenough took a most active part, and in spite of the opposition offered by the Royal Society, his exertions were rewarded by its complete organization. As an appropriate honour to one who had steadfastly supported its foundation, Greenough was elected the first president, a position which he continued to hold for several years.

Although possessing rich stores of information, accumulated during a long and zealous life, Mr. Greenough was not a great writer; but his profound acquaintance with the sciences of geology and geography is sufficiently attested by his valuable geological maps of England and Wales, and of India; the former published in 1819, and the latter in 1854, only one year before his death.

SIR HENRY THOMAS DE LA BECHE, C.B.—*By E. C. Papworth, from a bust by E. H. Baily, R.A. No. 219.*

This eminent geologist, the founder of this institution, was born in 1796. Having lost his father at an early age, he resided for some years with his mother in Devonshire, then at Charmouth, and afterwards at Lyme Regis. To his early associations may be referred those studies which became the business of his life; and it is interesting to witness the love with which he always returned to the consideration of the rocks of Western England, amongst which in his boyhood he had rambled; always finding, never seeking, pleasure. In 1810 Henry de la Beche entered the Military School at Great Marlow; but he never embraced the profession of arms, and in 1817, entering the Geological Society, he enrolled himself in that select band, who were then struggling to establish geology as a science, and of which he soon became a guiding spirit, and eventually the leader. Mr. De la Beche always exhibited great activity of mind, and numerous memoirs and other publications were continually proceeding from his pen.

In 1835 was commenced the great work of the Geological Survey of the United Kingdom, which may be regarded as one of the first scientific inquiries fairly recognized by the Government of this country. Mr. De la Beche was attached to the Ordnance Survey, with power to carry out a geological survey of the western counties, and to publish his results on the one-inch Ordnance maps, by

geological colouring. Upon this important point the words of his successor, Sir Roderick I. Murchison, spoken on receiving from the Geological Society the Wollaston medal for his friend, then in his last illness, are especially to the purpose:

"At his own expense he traced the boundaries and relations of certain rock formations, and laying them down on the Ordnance Survey maps, accompanied by illustrative sections, he thus took the first step in leading public men (otherwise little versed in our science) to see the good which must result from the extensive application of such a scheme, in making all proprietors alive to the importance of obtaining a better acquaintance with the subsoil of their estates.

"Having gradually attracted the notice of the Government, and having obtained the use of rooms in Craig's Court, and the employment of a limited sum of the public money, Sir H. de la Beche then attached to his new-formed establishment able men of science, who could decipher formations in the field, describe the fossils they contained, or chemically analyse the structure of the rocks and their associated minerals. Soon filling to repletion the small space allotted to him with models of mines, illustrative drawings, and specimens of fossils, ores, and building stones, he convinced our rulers, and particularly the illustrious statesman Sir Robert Peel, that the dignity and interests of the country required an adequate and appropriate building should be erected, and exclusively devoted to the fulfilment of a project so lucidly devised, and thus far so well realized. *Then arose very much after the design of the accomplished director himself, that well adapted edifice in Jermyn Street, which to the imperishable credit of its author, stands forth as the first palace ever raised from the ground in Great Britain by the Government, which is entirely devoted to the advancement of science.*

"Once possessed of halls worthy of so noble an object, Sir Henry De la Beche next rendered them practically useful to the public, and on a vastly extended scale, by embracing, as necessary adjuncts, metallurgy and mechanical science, in addition to the branches of knowledge previously cultivated."

For his zealous labours in the cause of geological science, the Director-General of the Geological Survey was knighted by his sovereign. On the continent, too, the labours of Sir Henry De la Beche were fully appreciated; he was created a knight commander of the Danish order of Danebrog, and of the Belgian order of Leopold; he was elected a corresponding member of the Institute of France, and member of various foreign Academies.

On the 13th of April 1855 Sir Henry Thomas De la Beche died; his mental energies remained unimpaired to the last. Thirty-six hours before his decease he visited the Museum, and spent upwards of an hour in carefully examining the results of a statistical inquiry into the coal and iron produce of this country by the author of this Guide. This was the last public labour which engaged the attention of that mind, of which the Geological Survey and the Museum of Practical Geology remain enduring monuments.

Another bust of Sir H. T. De la Beche, in bronze, presented by Mr. E. H. Baily, R.A., is placed in the Library of the Institution.

PROFESSOR EDWARD FORBES.—*An original bust by I. C. Lough, 1856. Presented by subscription. No. 162.*

EDWARD FORBES was Palæontologist to the Geological Survey of the United Kingdom, and lecturer on Natural History in the

Government School of Mines. He was born in the Isle of Man in 1815.

Edward Forbes was a naturalist from his childhood, always delighting in the works of creation spread around him. He spent some time at the University of Edinburgh, and in 1833 he travelled with a fellow student to Norway. Eight years after this he was appointed Naturalist to a surveying expedition to the Mediterranean. With Captain Graves, in H.M.S. "Beacon," he proceeded to the scene which he has marked by his important labours. In the Ægean he was able to determine some remarkable facts connected with animal life in the ocean, and to carry out those dredging explorations which enabled him subsequently to deduce some important considerations on the distribution of animal life in space and time. During this appointment he travelled in Lycia, and fixed the sites of several of the Cibiyratic cities. In 1843 Edward Forbes was appointed Professor of Botany in King's College. He shortly after became Secretary and Curator of the Geological Society, Palæontologist to the Geological Survey, and on the organization of the Government School of Mines, its Professor of Natural History. To the Memoirs of the Geological Survey Professor E. Forbes contributed several valuable papers; and under his care was commenced the publication of the Decades, illustrative of British organic remains.

On the death of Professor Jameson, the Regius Professor of Natural History in the University of Edinburgh, Edward Forbes was appointed to succeed him. This chair was the object of Forbes's ambition, but he was not destined long to enjoy it; he died on the 18th November 1854, only six months after his appointment.

Professor Edward Forbes's latest work, of which he left an outline sketch at the time of his death, "*On the Tertiary Flavio-Marine Formation of the Isle of Wight*," was completed by his colleagues, and published as one of the Memoirs of the Geological Survey.

Professor Forbes was succeeded in the chair of Natural History in the Royal School of Mines, by its present occupant, Professor T. H. Huxley, LL.D., F.R.S.

PROFESSOR J. B. JUKES.—*Cast from an original bust by Joseph Watkins. No. 64.*

J. BEETE JUKES was one of the many Cambridge men who acquired an enthusiastic taste for geology from the spirited lectures of Professor Sedgwick. Mr. Jukes entered St. John's College in 1830, having received his previous education at the Merchant Taylors' School in Wolverhampton, and at King Edward's School at Birmingham. Anxious to make geology his profession, he accepted in 1839 an appointment in Newfoundland, and devoted two years to the exploration of the island. In 1842 he published the results of his investigations in a work entitled "*Excursions in Newfoundland*." Soon after his return to England he was appointed naturalist to H.M.S. "Fly." The special object of the voyage which he then undertook, under Captain Blackwood, was to survey the great series of coral reefs which form a barrier running along the eastern coast of Australia for upwards of a thousand miles in length. The narrative of this expedition was admirably written by Mr. Jukes. He had not been long home from this voyage before he received an appointment on the staff of the Geological Survey, with which he remained connected during the rest of his life. His work as a Government surveyor lay among the old rocks of North

Wales and the coal-measures of Staffordshire. A valuable memoir by Mr. Jukes on the Geology of the South Staffordshire coal-field was published in 1853. When Professor Oldham left Dublin to take the superintendence of the Indian Survey, Mr. Jukes was appointed Director of the Irish branch of the Geological Survey. He was also Lecturer on Geology at the Royal College of Science in Dublin, and the author of some excellent educational works on geology. Mr. Jukes died on August 1st, 1869, and was succeeded in his official appointment by Mr. E. Hull.

WILLIAM SMITH, LL.D.—*An original bust by M. Noble.* No. 69.

WILLIAM SMITH was the author of the first geological map of England and Wales. He was born 23rd March 1769 at Churchill in Oxfordshire, and died 28th August 1839 at Northampton. At an early period, being employed to make careful surveys of collieries in Somersetshire, he was much struck with the constancy of the order of superposition of the strata; and this appears to have led him to a general examination of the country. In 1794 Mr. Smith was enabled, by one long journey through great part of England and Wales, to commence his "Geological Map of England and Wales," and to draw up a "Table of the Superposition of the Strata." It was not until 1815 that those labours were fully developed, when he published a "Delineation of the Strata of England and Wales," and a memoir on the subject. In 1831 the Geological Society of London awarded to Mr. W. Smith their Wollaston medal "in consideration of his being a great original discoverer in English geology, and especially for being the first in this country to discover and to teach the identification of strata, and to determine their succession by means of the imbedded fossils."

JAMES HUTTON, M.D.—*An original bust by Patric Park.* No. 76.

JAMES HUTTON was born 3rd June 1726 at Edinburgh, which University he entered as a student in 1740. Dr. Hutton devoted much attention to agriculture; and when seeking information on rural economy he appears first to have acquired a taste for mineralogy, and, as he himself expresses it, "became remarkably fond of studying the surface of the earth."

In 1777 Dr. Hutton gave to the world his first publication, "Considerations on the Nature, Quality, and Distinctions of Coal and Culm." During thirty years Dr. Hutton's attention was turned to geology, and this led him to communicate to the Royal Society of Edinburgh his "Theory of the Earth," that most remarkable and original work, which was in truth the foundation of modern geology. This was subsequently published in two volumes. Dr. Hutton died in 1797, and of him it is said:—"The greatest acquisitions of wealth and fortune never excited more lively sensations of pleasure in the minds of men than those which arose in the mind of Dr. Hutton on hearing of a new invention, or on being made acquainted with a new truth." "He would rejoice over Watts' improvements on the steam engine, or Cook's discoveries in the South Sea, with all the warmth of a man who was to share in the honour or the profit about to accrue from them."

PROFESSOR SEDGWICK, LL.D., F.R.S.—*Replica of original bust by T. Woolner. Presented by a Lady.* No. 160.

ADAM SEDGWICK, Professor of Geology at Cambridge for more than half a century, was the son of the vicar of Dent, a small town

in the north-western part of Yorkshire, where he was born on March 22nd, 1785. He received his education first at Sedburgh School, and afterwards at Trinity College, Cambridge. Having distinguished himself as a high wrangler, he was appointed, in 1818, to the Woodwardian Professorship in succession to Professor Hailstone. It is the function of the Woodwardian Professor to defend the views held by the founder of the chair as to the nature and origin of fossils, but previously to Sedgwick's appointment no systematic lectures on geology had been delivered. On receiving the appointment, however, Sedgwick applied himself with characteristic earnestness to the study of the science which was thus thrust upon him, and with such success that he was enabled, in 1820, to publish the results of some original observations on the physical structure of Devon and Cornwall. During the remainder of his days he devoted himself to the science which he thus took up, and continued as long as strength permitted to spend his leisure time in original field-work. By his researches among the old rocks of Cumberland and North Wales he was enabled to establish his "Cambrian System." As a lecturer he exerted peculiar influence, and many of his pupils, fascinated by his enthusiasm, have become geologists of the first rank. In 1833 Sedgwick presided over the meeting of the British Association at Cambridge, and the following year he was made a canon of Norwich Cathedral. The Woodwardian Museum as Cambridge was founded by Sedgwick in 1842, and to such an extent has this magnificent collection of organic remains since grown that new buildings are about to be erected for its accommodation. Professor Sedgwick died on January 27th, 1873, and was succeeded by Mr. T. McK. Hughes, formerly of the Geological Survey.

SIR JAMES HALL.—*An original bust by Patric Park.* No. 226.

JAMES HALL.—There were few men who united with more advantage chemistry and geology than Sir James Hall. At the period when the theories of the earth's formation were zealously discussed, Sir James Hall was induced to make some experiments of a very important character in connexion with the subject.

The results of these investigations will be found in the Transactions of the Royal Society of Edinburgh. Sir James Hall died in 1832; and as an attentive geological observer, and a zealous chemical experimentalist, his bust finds its appropriate place with the men of his time, Playfair and Hutton.

PROFESSOR J. PLAYFAIR.—*After Sir F. Chantry by M. Noble.* No. 228.

JOHN PLAYFAIR was born at Benvie, in Forfarshire, March 10, 1748. Dr. Wilkie, the Professor of Natural Philosophy at St. Andrews, finding himself unable to discharge the duties of his office, delegated them to Playfair, then a student; this fact proves the estimation in which he was then held. In 1773 Playfair obtained the living of Liff and Benvie, and in 1779 he communicated his first paper to the Royal Society of London. In 1785 he was appointed Professor of Mathematics, jointly with Dr. Ferguson, in the University of Edinburgh; and on the death of Mr. Robinson in 1805 he succeeded him to the chair of Natural Philosophy in that university. He was the intimate friend of Hutton and the strenuous supporter of the geological theory which bears that philosopher's name. Playfair's "Illustrations of the Huttonian Theory of the Earth" have been much admired for the clearness with which the system was unfolded. His works were of a mis-

cellaneous character, chiefly connected with mathematics and the higher branches of natural philosophy. The death of Professor John Playfair took place at Edinburgh on the 19th July 1819.

WILLIAM BUCKLAND, D.D., F.R.S.—*A bust by H. Weekes, B.A., 1860. Presented by subscription. No. 232.*

WILLIAM BUCKLAND was born at Axminster on the 12th March 1784. His taste for geological pursuits appears to have been developed at an early age, for we find him when a youth at Winchester College occupied in collecting the chalk fossils of the neighbourhood, and on his subsequent removal to the University of Oxford the fossils of the oolites enabled him to pursue his favourite employment. At Oxford he attended the mineralogical lectures of Dr. Kidd, and on that gentleman's resignation in 1813 Buckland was appointed to the vacancy. About this time the importance of geological science began to be recognised at the university, and in 1818 a special readership in geology was founded, to which Dr. Buckland was advanced. His inaugural address on this occasion was afterwards published under the title of "*Vindiciæ Geologiæ, or the Connexion of Religion with Geology explained.*" A few years later he gave to the world the interesting results of his original researches on bone caverns, in the form of a valuable treatise, entitled "*Reliquiæ Diluvianæ, or Observations on the Organic Remains in Caves, &c., attesting the action of an universal Deluge.*" Some of the views there maintained he was subsequently induced to modify, as seen in his later work, the admirable Bridgewater treatise on "*Geology and Mineralogy considered with reference to Natural Theology.*" Dr. Buckland's zeal as a practical geologist and his ability as a writer are seen not only in these larger works, but also in the number of valuable papers which he was constantly contributing to the Geological Society. Towards the close of life, however, his mental activity declined, and after several years of retirement from geological pursuits he expired on the 14th August 1856, having been Dean of Westminster for eleven years.

#### GRANITE.

In its typical varieties granite consists of a crystallo-granular mixture of the three minerals, *felspar* (p. 136), *quartz* (p. 131), and *mica* (p. 137). The felspar, which usually forms the chief constituent, is in most cases the common potash-felspar called *orthoclase*; but this is frequently associated with a soda-bearing species which is commonly *oligoclase*, but in some cases appears to be *albite* (p. 136). The orthoclastic felspar often occurs in large well-formed crystals embedded in a fine-grained base, thus producing the beautiful *porphyritic granites*, of which some fine examples are exhibited (p. 27).

Certain varieties of granite rapidly suffer disintegration, while others are remarkable for their extreme durability. Combined with a considerable degree of hardness, this durability renders granite highly valuable as a building stone for bridges and other massive structures, while the toughness of the hornblendic varieties makes them especially suitable for road materials. At the same time the beauty of many granites, and the high polish which their hardness renders them capable of receiving, recommend their use for purposes of ornament. The industrial applications of granite are, however, greatly restricted by its expense.

GRANITES OF SCOTLAND.—*Steps at Entrance. Pilasters on each side of Stairs from Hall, and Nos. 36 and 125.—Screen 4.—Slabs surrounding tessellated pavement.—Pedestals, Columns, &c., Nos. 9, 84, 94, 111, 112, 119, 152, 153, 157, 202, 210, 212, and 231, Cubes in Table Cases III. and VII.*

The granite of Aberdeen, especially that from the quarries of Dancing-Cairn, Rubislaw, and Tyrebagger, is much used in the metropolis for kerb and paving stones; the usual colour is grey, but some red granite is also quarried. Around Peterhead the red granite prevails, hence it is usually distinguished as the *Peterhead granite*. The principal quarries are those of Black Hill, four miles west of Peterhead, belonging to the Governors of the Merchant Maiden Hospital of Edinburgh, those on the estates of the Earl of Errol, at Boddam, at Longhaven, at Cairngall, and at Rova. The Sheerness Docks were built mostly with stone from these quarries. The Stirling Hill quarries, at Boddam, furnished the pillar of the Duke of York's monument, the Seafield quarries the abacus. The beautiful pillars in the library of the British Museum were obtained from Longhaven; the cost for transport at the time they were worked being something almost fabulous, so great were the difficulties attending their removal. The pillars in Fishmongers' Hall are from the Stirling quarries, as are also the bases of the monuments of Pitt and Fox; while the polished pillars of the Carlton Club House are from the quarries near Peterhead.

The fine pink and red granites of the Isle of Mull have been largely worked by the Scottish Granite Company, and were employed in the erection of the Albert Memorial in Hyde Park. Specimens of Scotch granites are exhibited from the following localities:—Peterhead, Aberdeen, and Corrennie Hill, Aberdeenshire; Portsoy, Banffshire; Dalmore, Sutherland; Oban and Mull, Argyllshire; Tiree, Hebrides; and Craignair, Kirkcudbrightshire.

GRANITES OF IRELAND.—*Base of Sides in Vestibule. Column No. 1. Slabs Nos. 33 and 33A. Cubes in Table Case III.*

The granitic rocks of Ireland occur in four districts, namely:—in Donegal, on the north-west; in Galway and Mayo, on the west; in Wicklow and Wexford, on the south-east; and in Down and Armagh, on the north-east. (*Hull's Building and Ornamental Stones*, 1872.)

The most extensive granite district in Ireland, and indeed in the whole of the British Islands, stretches south from Dublin, through the counties of Wicklow and Carlow into Kilkenny and Wexford, occupying an area 70 miles in length, and from 7 to 17 miles in width. The granite of the Wicklow range is the most extensively used. It varies in its quality, that near Kingstown being coarse and hard, while that from Ballyknockin or Golden Hill is much finer, and therefore fitted for ornamental work.

Killiney Hill, near Dublin, has yielded enormous quantities for the harbour and pier of Kingstown, and for numerous buildings in and around Dublin. It has also been employed in the Thames Embankment.

In Galway at least two varieties of granite have been recognized, but the characteristic Galway granite is a handsome porphyritic rock with large crystals of red orthoclase. This rock has been quarried at Furbogh, eight miles from Galway, and a column (No. 1) showing the appearance of the granite when polished will be found in the Hall.

Passing to the north-east of Ireland we find granitic rocks forming three distinct tracts in the mountain ranges of Mourne, of Carlingford, and of Slieve Croob. It is the last only which is largely worked.

The granite of Newry is extensively quarried, and sent by water to the north of Ireland, whilst a quarry at Castlewellsan has yielded much of the granite used for the base and pedestal of the Albert Memorial.

The following localities are represented in the collection:—Kings-town, Killybeg, Dalkey, Kilgobbin, and Glencullen, co. Dublin; Glenageary and Ballyknockin, co. Wicklow; Ballyholland, near Newry, co. Down; and Galway.

GRANITES OF CORNWALL AND DEVONSHIRE.—*Pedestals and Columns Nos. 3, 10, 134, 148, 150, 164, 166, 171, 172, 180, 190, 192, 216, and 227. Cubes in Cases III. and VI.*

By reference to the Map of the Geological Survey the granite districts of western England—coloured pink—will be seen, appearing as five islands of granite rising out of the surrounding killas or clay slate; and around these are a few smaller outlying masses.

The more important quarries from which this durable stone is obtained are those of Lamorna, to the west of Penzance; the Penryn quarries; the quarries near St. Austell; Hensborough, near Lostwithiel; the Cheesewring, near Liskeard; Gunnis Lake, near Calstock; the Delank quarries near Padstow; and the Dartmoor quarries in Devonshire.

The following is from the pen of Sir Henry De la Beche (*Report on the Geology of Devon, Cornwall, and West Somerset*).

"There is much good granite on Dartmoor, though it is not always sufficiently accessible to be carried long distances; the chief places where it is worked in large quantities and afterwards exported are, Hey or High Tor on the east, and near King Tor on the west. The granite from the former place is conveyed by a tramroad to the Stover canal, down which it is carried in boats, and afterwards down the Teign to Teignmouth, to be shipped for its destination. That from the west side of the moor is conveyed by the Prince's Town and Plymouth tramroad to the latter place and shipped.

"The continuation of the Hingston Down granite is worked up the Tamar near New Bridge and exported from Morwellham. A very hard variety is obtained upon the higher part of the Down, and has been employed advantageously for pavements. \* \* \*

The chief quarries in the eastern or hard part of the Hensborough mass of granite are those of (the late) Mr. Austin Treffry, up the Par Valley, commonly known as Lostwithiel granite. Extensive quarries are there worked, and the stone is brought to the head of the canal near Pons-mill, upon which it is conveyed to Par harbour, and there shipped. \* \* \* The Carn Menezes mass has furnished the granite most commonly known as Cornish. It is nearly altogether shipped at Penryn, where it is brought variable distances from different quarries in the vicinity, many situated in the parish of Mabe."

Since the above report was written the quarries on the eastern edge of Dartmoor have ceased working; those at the Cheesewring near Liskeard have been opened, and stone of a beautiful quality is raised and exported in large quantities from Looe. The Lamorna quarries to the west of Penzance and a large quarry, Mill Hill, in Madron, have also been worked. The stone obtained from those

quarries is of excellent quality, and it can be obtained of very large size.

The following great works, amongst many others, have been constructed entirely or in part of Cornish granites: The Penryn and Lamorna granites have supplied Portland breakwater; Keyham Docks for the Steam Navy; Commercial Docks, London; the Hull, Great Western, and Birkenhead Docks, and the National Works at Chatham and Portsmouth, together with the Scutari monument. The plinth for the railings of the British Museum is from the Carnsew quarries, and the towers, including the lodge for gates, &c., from Constantine. The Constantine granite has been used for the Wellington Memorial at Strathfieldsaye, the shaft of the column being 30 feet in height in one stone.

The Cheesewring granite has been used in the London Docks, Westminster Bridge, the Thames Embankment, Rochester Bridge, the docks at Copenhagen, the Great Basset Lighthouse near the island of Ceylon, and for the tomb of the Duke of Wellington in the crypt of St. Paul's Cathedral. These quarries produce from 8,000 to 10,000 tons of stone per annum, and about a similar quantity is annually shipped from the quarries near Par.

Cornish granites are exhibited from the following localities:—Lamorna Cove, Paul, Castle-an-Dinas, Marazion, Madron, Ludgvan, Constantine, Carnsew, Mabe, Penryn, St. Austell, St. Blazey, Lanlivery, Luxullian, Roach, Lanivet, Withiel, Bodmin, Castle Quarry, St. Breward, Cardynham, St. Neots, Trewoon, Trowlesworthy, Halvasso, and the Cheesewring.

Devonshire granites are exhibited from the Fremator quarries near Tavistock, and from Blackenstone and Heytor, Dartmoor.

In addition to the granites from our western counties noticed above, a few other specimens are exhibited from localities of much less importance. *Shappell*, in Westmoreland, furnishes a beautiful porphyritic granite represented by the Column No. 204, and by the plinth of the pedestal which supports the bust of Prof. Sedgwick. The Shap granite is now worked, and for this purpose a company has erected cutting and polishing machinery by the side of the Lancaster and Carlisle Railway, near Shap Station. *Mount Sorrel*, near Charnwood Forest in Leicestershire, yields a pink syenitic granite, which has been employed in the decoration of the eastern wall. The base of the pedestal No. 161 is from the boss of granite which penetrates the surrounding schists on the south-eastern side of South Barrule, one of the highest points in the *Isle of Man*. The granite of *Lundy Island* is represented by several cubes in Cases III. and VII. As these specimens were all obtained from near the exposed surface they sufficiently attest the durability of the stone, but probably much better varieties would be found at greater depths.

From the *Channel Islands* large quantities of granite are exported, chiefly for use as London road-metal. Specimens are exhibited in the table-cases from the quarries of Mount Mado and La Perruque in Jersey, and from Guernsey and its dependency, the little island of Herm.

PORPHYRIES. ELVANS. SYENITES. GREENSTONE.—*Columns, Slabs, &c.*  
Nos. 1, 95, 123, 134, 135, 136, 150, 154, 166, 172, 192, and 204.  
*Cases III., VII.*

Under the generic term *Porphyry* are grouped all those varieties of rocks that consist of a matrix in which distinct crystals are embedded; the term thus referring rather to the physical structure of

the rock than to any more essential character, and hence embracing many varieties which in chemical composition are widely distinct. True porphyry consists of crystals of felspar in a felspathic base: the type of this rock being the ancient red porphyry of Egypt. Many of the Cornish and Devon granites in the collection are eminently porphyritic, and we may especially notice the pedestal and columns Nos. 172 and 192 on the eastern side and Nos. 150 and 154 on the western side; the latter two, from Lanlivery and Luxulian in Cornwall, have been employed, especially by the late Mr. Austin Treffry, for ornamental purposes. The sarcophagus for the late Duke of Wellington, now in St. Paul's, is formed of one huge mass, of the same character as the red and black variety in the column, No. 154, and in the bases of the pedestals Nos. 166 and 172. This beautiful rock, which, from its locality, has been called *Luxulianite*, consists of large crystals of pink orthoclase-felspar, associated with much schorl, or black tourmaline, and a small quantity of quartz.

Upon reference to a good Geological Map of Cornwall a number of bands will be seen traversing both the granite and slate rocks of Cornwall, having a main general direction from the north of east to the south of west. These represent dykes of what is locally termed *Elvan*, a rock closely allied to granite, from which indeed it principally differs in the general absence of mica. Frequently the elvans become porphyritic, being chiefly composed of a felspathic or a quartzo-felspathic base, containing crystals of felspar and quartz, sometimes schorl, and occasionally, though rarely, mica.

Sir Henry De la Beche remarks of the Cornish elvans, "For durable stone the harder elvans of this district, particularly when of good cream and other light colours, may be considered as the best building materials in it: their durability and appearance may be seen in many churches and old mansions, where the finer carvings of the ornamental parts are as sharp as the day they were put up. Occasionally the felspar crystals may have been decomposed and have been washed out, but the siliceo-felspathic base has remained firm, thus preserving the sharp character of the work." The Cornish elvans have been recently described before the Royal Cornwall Polytechnic Society by Mr. A. K. Barnett; and much useful information upon the building and ornamental stones of Devonshire and Cornwall in general will be found in *The Report on the Geology of Cornwall, Devon, and West Somerset*, by Sir Henry T. De la Beche.

In the Table Cases III. and VII. will be found specimens of elvans from Mayen, Land's End; Marazion, near Penzance; Breague, near Helston; Porkellis, Wendron; Roscrow and Trevailes, Penryn; Newhaven, Truro; near Newquay; Pentuan, and Dowgas Mine, St. Austell; Withiel, Lanivet, St. Neots, and Tre-more, near Bodmin; St. Dennis; Camelford; and Meldon, Okehampton, Devon.

Granites frequently contain various accessory minerals, of which one of the most common is the lustrous mineral *hornblende*. This sometimes occurs to the entire exclusion of the mica, and the rock thus formed, consisting essentially of an aggregate of felspar, quartz, and hornblende, is commonly termed *Syenite*, a name derived from the ancient quarries of Syene in Upper Egypt, whence a hornblendic granite was formerly obtained. Several examples of syenitic granites will be found in the collection amongst the Guernsey and Irish specimens. It should be observed that many petrologists restrict the term syenite to a rock composed only of

orthoclase and quartz. When the rock consists of felspar and quartz, but the felspar is oligoclase instead of orthoclase, it generally passes under the name of *Greenstone* or *Diorite*, of which an example from Llanwnda, in Pembrokeshire, will be seen in the copy of a bust of Bubastis (No. 95) near the western entrance to the theatre. The Penmaen-mawr stone (No. 123, beneath Case VII.) is a felspathic greenstone, which, from its toughness, forms a valuable paving material. It occurs as an intrusive mass in the Lower Silurian rocks near Conway, in Caernarvonshire.

## SERPENTINE.

CORNISH SERPENTINES.—*Slabs, Columns, Tazze, &c., Nos. 20, 67, 83, 92, 93, 137, 149, 156, 158, 181, 191, 195, 209, 215, 220, 223, and 225. Screen on Eastern Wall. Cubes in Case III.*

The Serpentine,—so called from the supposed resemblance of the rock to the skin of a serpent,—which is found in quantity at the Lizard, is undoubtedly the most beautiful of the ornamental stones of this country. The variegated colours on which its elegance depends, are usually dark rich shades of red and green, irregularly mingled, and often relieved by white veins of *steatite* or soap-stone. Near to, and to the eastward of, Cadgwith a very beautiful variety of reddish serpentine occurs, studded with brilliant laminae of *diallage*, a silicate of lime, magnesia, iron, &c., allied to augite. Both the serpentine and the associated *steatite* are essentially hydrous silicates of magnesia. Formerly the *steatite*, from the “Soap Stone Rock,” near Mullion, was sent in considerable quantities to Bristol, where it was used in the manufacture of carbonate of magnesia; and at one period was employed at Worcester in the manufacture of porcelain, but it is no longer worked.

For purposes of ornament this elegant stone is well adapted, being moderately soft, but not brittle, and therefore easily worked, while it is sufficiently hard to receive an excellent polish. It was long thought that blocks of serpentine of a large size could not be obtained; quarries have, however, been opened, and it is found that the size and solidity of the blocks increase with the depth from the surface. There are few spots around the British coast more beautiful and grand than Keynance Cove near the Lizard, where the serpentine rock in all its varied dyes, is polished by the beat of the Atlantic waves, and, in contrast with the white sands of the shore, is rendered still more striking and characteristic.

IRISH SERPENTINES.—*Pilasters Nos. 43 and 116. Screen on E. Wall. Slabs, Columns, &c., 74, 118, 178, 182, 208, and 218. Tazza, 178.*

Serpentine frequently occurs in intimate association with limestone, forming a mixed rock often of great beauty. The celebrated *verd-antique* (*verde antico* of the Italians) is a rock of this kind (see Nos. 18 and 19). Somewhat similar serpentinous marbles occur in Ireland, especially in Galway and Donegal, which afford beautifully variegated green and white specimens. The green Connemara marble, known to architects as “Irish Green,” is obtained at Ballinahinch, Letterfrack, and other localities in Galway, the most valuable quarries being situated near Clifden, whence this fine material is exported.

ANGLESEY SERPENTINE.—*Pedestal No. 196. Slab No. 224.*

Among the metamorphosed Cambrian rocks of Anglesey a greenish serpentine occurs at several localities, frequently associated with

limestone. An example of this green serpentinous marble is furnished by the pedestal before us, from Rhoscelyn, near Holyhead.

SCOTCH SERPENTINES.—Obelisk No. 91. Cubes Nos. 90 and 151.

Serpentine rocks occur in various localities in Scotland, especially in Banffshire and Aberdeenshire, and again in the Shetland Isles, where they form the matrix of the chrome iron ore. As will be seen from the specimens, very fine varieties for ornamental purposes are obtained from Portsoy, on the north coast of Banffshire, whence this elegant material was formerly exported.

### MARBLE.

It is a common practice to comprehend under the name of *marble* every stone which is capable of receiving a polish and of being applied to purposes of decoration, such as serpentines, porphyries, alabasters, and other ornamental stones. In strictness, however, the term should be limited to those varieties of carbonate of lime which are sufficiently hard and compact to be susceptible of polish.

Although by no means restricted to any particular strata, yet the marbles of this country are usually obtained from the palæozoic rocks, being especially abundant in the Carboniferous and Devonian systems. The Carboniferous or Mountain Limestone—which rises in our northern counties in a broad ridge or anticlinal curve forming the Pennine chain—furnishes valuable marbles in certain districts, especially in Derbyshire and on the borders of Staffordshire; whilst the fossiliferous limestones of the Devonian system—still older than those of the Carboniferous series—yield the valuable marbles of South Devon.

DERBYSHIRE MARBLES. *Pilaster* 99. *Columns, &c.* Nos. 5, 35, 42, 54, 58, 60, 63, 77, 79, 80, 81, 86, 89, 98, 108, 110, 115, 117, 121, 128, 142, 143, 200, 214, 222, and 229. *Tazze, &c.* Nos. 82, 87, 167, 173, 183, 185, 193, 197, 203, 205, 207, and 230. *Screen* 3. *Inlaid Work*, Nos. 21, 66, 97, and 107. *Cubes in Case I.*

The rocks of Derbyshire are rich in ornamental marbles, which, from their beauty, and in many respects their curious characters, have been largely employed for decorative purposes. They are usually distinguished by their colour—as white, grey, dove, blue, black, and russet marbles; or by physical peculiarities, dependant mostly upon their fossil contents, as bird's-eye, dog-tooth or mussel, entrochal, shelly, and breccia marbles. The limestone rocks of Derbyshire are divided into four classes, known as the 1st, 2nd, 3rd, and 4th limestones, which are separated from each other by an amygdaloidal greenstone, called *toadstone*,—probably a corruption of the German *Todtstein*, or dead stone, in allusion to these interbedded trap rocks being barren of lead ore compared with the adjacent limestones. The ornamental marbles are, however, mostly confined to the first three formations. From the upper beds of the 1st and 3rd series is principally obtained the well-known *entrochal* or *enorinital* marble, so called from the presence of abundant fossil remains of encrinites, or “stone lilies.” These were echinoderms belonging to the Crinoidea,—an order of which there are but few living representatives, compared with the abundance which existed in the Palæozoic and Secondary periods of the world's history; the beautifully-formed and numerously-jointed *Pentacrinus caput Medusæ*, which is occasionally dredged from great depths on the coral reefs of the West India Islands, being the finest living example of

this ancient family. The encrinite consisted of a long jointed column attached by one extremity to the sea-bottom, and supporting at the opposite extremity a cup-shaped body, from which radiated several articulated arms furnished with ciliated appendages. The entire structure was rendered flexible by the internal calcareous skeleton being composed of numerous cylindrical or bead-like joints. Mr. Parkinson states that the upper part of the skeleton of one species of encrinite consisted of nearly 27,000 ossicles or small bones. These being dislocated are cemented together, in the marble, by carbonate of lime; and being, in the process of manufacture, cut in many different sections, and polished, they assume a variety of forms. Many beautiful examples of these encrinital marbles will be found in the collection.

The perforations in the centre of the joints afford facilities for stringing them as beads; in this way these fossils were used as rosaries, and they are still known in northern England as St. Cuthbert's beads.

The black marble is obtained from the second limestone, especially in descending into Monsal Dale from Little Longsdon. Machinery for cutting and polishing this marble was first used at Ashford in the year 1748. The shell-marble is also yielded by this series of rocks; this variety contains the remains of *brachiopodous* molluscs, so called from having two long ciliated arms (*βραχίον*, *brachion*, an arm, *ποὺς*, *pous*, a foot). These are "shell-fish," furnished with two valves which are never quite equal, but since each valve is equal-sided the forms are symmetrical. In these points they differ from the ordinary bivalves, which are mostly equivalved but never quite equilateral. From the resemblance of these brachiopodous shells to antique lamps, they are commonly called "lamp-shells;" the hole corresponding to that which in a lamp admits the wick, serves in the lamp-shell for the passage of the pedicle by which the animal attaches itself to submarine objects. The *Spirifer* and *Producta*, two genera of the above class, are the most abundant in these limestones.

The three upper limestones, from which these marbles are obtained, extend, according to Farey (*General View of the Agriculture and Minerals of Derbyshire*), over an area of nearly 51,500 acres.

In this collection the following localities are represented, viz.,—Wirksworth, Middleton, Bonsall, Matlock, Nether Haddon, Allport, Monyash, Oneash, Sheldon, Ashford, Flagg, Stony Middleton, Buxton, Miller's Dale, Ricklow Dale, and Tideswell.

A cube of encrinital marble, extremely similar to some of the Derbyshire marble, from the mountain limestone of Dent, in the west of Yorkshire, is placed with the specimens from Derbyshire in Case I. As Dent was the birth-place of Professor Sedgwick a pedestal of this marble has been selected as an appropriate support to the bust of this distinguished geologist. (No. 159).

STAFFORDSHIRE MARBLES.—Columns Nos. 146 and 206. Tazza 201. Inlaid work, 97 and 107. Cubes in Case II.

The marbles of Staffordshire present but little variations from those of the adjoining county. Their geological positions are the same, and they present similar general characters. Specimens are exhibited from Wetton and Ecton.

The variety of coloured limestones which the two counties of Derbyshire and Staffordshire produce has naturally led to a manufacture almost peculiar to them. Mosaic work of a very beautiful

description is executed in these materials. Indeed, many of the inlaid tables, tazze, and other ornaments, produced from Derbyshire and Staffordshire materials, are worthy rivals of the far-famed Florentine works. In addition to the inlaid tables in this hall, there will be found some interesting specimens of this kind of work in the horse-shoe case on the principal floor (p. 130).

DEVONSHIRE MARBLES.—*Pilasters*, 44 and 109. *Screen* 2. *Columns*, *Slabs*, &c., *Nos.* 7, 8, 75, 127, 131, 132, 139, 140, 141, 144, 189, and 198. *Inlaid Table*, 106. *Cubes in Case I.*

The limestone formations of Devonshire, from which ornamental marbles are obtained, may be said to be confined to the districts extending from Torbay to a few miles beyond Newton Bushell and Totness, and to the neighbourhood of Plymouth. These limestones belong to the group of strata known to geologists as the *Devonian system*. The limestones of the Carboniferous series of North Devon are rarely worked for ornamental purposes.

Marble works are extensively carried on at St. Mary Church near Torquay, the Babbacombe limestones yielding some interesting varieties of the red, grey, and variegated marbles. Many blocks are almost entirely formed of fossil corals; these are known as *madrepore marbles*; and Mr. Godwin Austen, who has examined these formations with great care, has clearly shown that the origin of both the Torquay and Plymouth marbles is of an analogous character to that of the coral formations now taking place in the Pacific Ocean.

At Ipplepen there is an extremely handsome variety of a reddish marble, and some of a nearly similar character occurs near Totness. The limestones of Plymouth are not generally so handsome as those of Babbacombe, but many very fine examples may be obtained. The quarries of Oreston, near Plymouth, furnished the stone employed in the construction of the Plymouth breakwater, and in connexion with the use of this limestone for that purpose, one curious circumstance has attracted attention. Between high and low water-mark the boring molluscs (*Pholas dactylus*; pholas from *pholeo*, to bore) so perforated the limestones that it was thought necessary to replace them by blocks of granite, which, being much harder than the shells of these animals, resists their action. Some examples of these boring animals, and of the rocks perforated by them, will be found in the wall-case 43, in the upper gallery, eastern side.

Devonshire marbles are exhibited from Babbacombe, Bradley, Ipplepen, Buckfastleigh, Oggwell, Chudleigh, Kitley Park, and Plymouth.

MARBLES OF BRISTOL, ISLE OF MAN, &c.—*Cubes in Case II.* *Pedestal* 161. *Columns* 13, 22, and 145.

The rocks which rise on either side of the Avon have been always celebrated for their picturesque character. This is not entirely dependent upon their bold outlines; their varied colours and their irregular forms adding greatly to the grandeur of the scene. Several varieties of ornamental marbles are exhibited from the rocks of this district, especially from the carboniferous limestone of Clifton. Like those already described, these marbles are fossiliferous; encrinites are often common, fish-palates are detected in some, and many of the beds of coralline limestone are extremely interesting from the resemblance they bear to coral reefs. The Bristol marbles,

like those of Derbyshire, and unlike those of Devonshire, belong to the carboniferous formation.

Among the British marbles in Case II. will be found a specimen of the argillaceous limestone commonly called "*Landscape marble*," in allusion to the peculiar dendritic markings which it exhibits. It occurs in the Penarth or Rhætic beds (p. 180), in the neighbourhood of Bristol; and was formerly much used for the manufacture of small ornaments. The *Ammonite marble* (No. 14) takes its peculiar character from the vast numbers of Ammonites which it contains; these fossils, somewhat resembling the shells of the living nautilus, will be described in another place (p. 176). Attention may also be directed to the specimens of conglomerate from Glamorganshire (Nos. 129 and 199), which belongs to the New Red Sandstone series, and rests frequently on the upturned and denuded edges of the carboniferous limestone. The fragments forming the conglomerate or "pudding stone" are united by a cement sometimes calcareous, but usually magnesio-calcareous or dolomitic. A fine slab of this dolomitic conglomerate is exhibited from Draycot, near Wells (No. 12). With these dolomitic conglomerates may be noticed some specimens of the peculiar breccia-marble of the Isle of Man (No. 22). The black marble from the Carboniferous Limestone of the Isle of Man has been selected as an appropriate material for the pedestal (No. 161) supporting the bust of Professor Edward Forbes, who was a native of the island.

In Case II. will also be found a few other marbles of less importance than those already noticed. These are from Somersetshire, Herefordshire, and South Wales. The carboniferous limestone of the Isle of Anglesey has furnished the black marble employed for the columns Nos. 13 and 145.

IRISH MARBLES.—*Pilaster* 48. *Columns, &c.*, 37, 68, 100, 133, 184, 186, 187, and 194. *Cubes in Case II.*

Ireland is rich in marbles; indeed in no other part of the British Islands is the carboniferous limestone developed on so grand a scale. Extending over a great central plain, 120 miles E. and W. from Dublin to Galway bay, and about the same distance north and south, it forms the characteristic rock throughout the greater part of the island, and attains in the southern counties the prodigious thickness of nearly 3,000 feet. The more valuable quarries are in the counties of Kilkenny, Carlow, Galway, and Mayo; from these several varieties of marble are raised, especially the black marble, next to which in importance are the dove, mottled grey, and white marbles. The Galway marbles are well known, but the beds in the quarries are usually thin. It is quarried principally at Menlo, on the banks of Lough Corrib. The black marble of Kilkenny owes its colour to the presence of organic matter, and as this gradually becomes altered by exposure to the atmosphere the colour suffers in similar degree. White marble is obtained in Connemara and in Donegal; the limestone of the former district is hard and fine, and is the strongest which has been found, while that of the latter is so exceedingly coarse that it cannot be used for fine work. The white Connemara marble cannot, however, be procured in large blocks free from streaks, which pass through the blocks parallel with the beds. Those counties also produce the bluish white and pink tinted marbles.

Black marble is principally obtained from Kilkenny, Galway, Churchtown, Donerail, Kerry, and Tipperary; white marble from Connemara, Donegal, Churchtown, and Kerry; and coloured marbles

are scattered over all the districts in which the limestones occur, the reddish varieties being found principally near Armagh, and at Middleton and Churchtown in co. Cork. The *sienna marble* comes chiefly from King's co.

The serpentinous marble of Connemara has been already noticed at p. 29.

Irish marbles are exhibited from Clonony, King's co.; Phoenix Park and Finglass, Dublin; Mitchelstown, Cork; Kenry and Askeaton, Limerick; Minto, Galway; Ballinahinch; the Twelve Pin Mountains; and Rossvella and White Craig Quarries.

SCOTCH MARBLES.—Screen 4. Block No. 17. Cubes in Cases II. and III.

An interesting variety of marble is exhibited from Tiree, in the Hebrides, where it occurs associated with the Laurentian gneiss.

The Tiree marble consists of a base of pink limestone, through which are disseminated granular masses of a dark green augitic mineral, giving the stone a porphyritic appearance. The bust of Sir H. T. De la Beche in the library of this institution is supported on a fine block of this marble.

#### ALABASTER.

Sides of Vestibule. Columns Nos. 88, 177, and 188. Tazza 170. Slab 65.

The term *alabaster* was formerly applied to a stalagmitic variety of carbonate of lime much used by the ancients for ornamental purposes, especially for the manufacture of small vases for holding precious ointments; whence such vessels received the name of "alabastra." This *Oriental alabaster*, of which the Algerian "onyx-marble" is a well-known modern example, must be carefully distinguished from the totally distinct mineral which is at present called alabaster; that name being now applied to the fine massive or granular-crystalline varieties of *gypsum* (p. 43). This mineral, which occurs abundantly in the New Red or Keuper marls of our midland counties, is a hydrous sulphate of lime, containing, when pure, sulphuric acid 46·51, lime 32·56, water 20·93. Owing to the presence of oxide of iron and other impurities, the mineral is rarely uniform in tint, but is generally clouded and streaked with red, as seen in the specimens exhibited. These are from Fauld, in Staffordshire; and Chellaston Hill, near Ashbourne, in Derbyshire.

The principal demand for alabaster is by the potters in Staffordshire, who form their moulds of plaster of Paris from it. It is therefore called *potter's stone*, and sells at about 9s. per ton of 2,400 lbs. (the long ton). In working the potter's stone the fine blocks are selected, and sold to the turners of alabaster ornaments. No. 188 is an illustration of the process of working and polishing this material for ornamental purposes.

Several varieties of alabaster occurring in Italy are extensively worked into ornamental objects, and as the stone is extremely soft, being indeed readily cut with a penknife, the cost of working is but small, and alabaster ornaments are therefore imported into this country at a low price. The purest white alabaster is worked at the Val di Marmolago, near Castellina, 25 miles from Volterra, in Tuscany.

#### SLATE.

This valuable material is a highly indurated argillaceous rock, readily cleaved in certain directions into thin laminae or plates;

and upon this peculiar fissile structure depends to a great extent its economic value.

The beds, deposited originally as a fine muddy sediment, appear to have been subjected, long after consolidation, to the action of intense lateral pressure, the effect of which was not only to contort the beds, but also to induce a re-arrangement of the particles of the rock, the flattened sides of these particles being forced by the lateral compression into positions transverse or at right angles to the direction of the pressure, and hence the rock readily cleaves parallel to that direction in which all the particles are thus definitely arranged. All contorted strata are not, however, cleavable.

Experiments on slaty cleavage by Mr. Sorby, Dr. Tyndall, and other physicists have shown that a similar, though much less perfect, fissility may be artificially developed by simple mechanical compression, the direction of the induced cleavage being always perpendicular to that of the applied pressure. The perfection of the natural cleavage is admirably shown by the Welsh specimens near the western window.

For further information on this subject, see *Descriptive Guide to the Rock Specimens*, 3rd edition, p. 13.

Slates are subject to considerable variation both in colour and texture: good roofing slate should absorb but little water, and be so compact as not to be decomposed by the action of the atmosphere.

Mr. McCulloch informs us that the use of slates in covering houses is entirely European; from the Hellespont to China there is not a single slated house, although slate is as abundant in Asia as it is in Europe. The duty on slates carried coastways was repealed in 1831, and since that time it has been extensively employed for various purposes to which it was not formerly applicable. Slabs which are not fit for splitting into roofing slates are now used as floorings, being cut with a circular saw into pieces of from half an inch to two inches thick.

SLATES OF NORTH WALES.—*Column No. 15. Collection at the south, or Jermyn Street end of Hall, west side.*

The slate quarries of North Wales have long been celebrated for the excellent character of the slates which they produce. The most important quarries are the following, which are given with their shipping ports, and the geological formations to which they belong:—

Penrhyn	- Bangor	} Cambrian.
Llanberis	- Dinorwic	
Ffestiniog	- Port Madoc, Lower Silurian.	
Llangollen	- Llangollen, Upper Silurian.	
Machynlleth	- Aberdovey, Lower Silurian.	
Royal Slate	- Bangor, Cambrian.	

There are many smaller works near Conway and Caernarvon. The slate quarries of North Wales produce at least 350,000 tons of roofing slates and slabs per annum. The annual produce of this district may be valued at 700,000*l.*, and there are employed in the production of slates and slabs upwards of six thousand men and boys in North Wales alone.

DELABOLE SLATE, of the Devonian Rocks. *East side of Case VI.*

The Delabole slate quarries, situate near Tintagel, in Cornwall, have been long celebrated for producing a durable material combining considerable lightness with strength. In 1602 Carew, in his

*Survey of Cornwall*, speaks of *healing stones* (in many districts roofing slates are still called *hailings* or *healings*, probably from *helo* or *heil*, to hide, and hence the name of *helier* given to a tiler or slater):—"In substance thinnè, in colour faire, in waight light, in lasting long, and generally carrieth so good regards as (besides the supply for home provision) great store is yearly conveyed by shipping both to other parts of the realme, and also beyond the seas, into Britaine and Netherland." Borlase, in 1758, speaks of the extent of the workings of Delabole. The Delabole quarries produce not only roofing slates, but flagstones or brick slates, which are highly esteemed for pavements in passages, courts, yards, &c. and for tombstones. The inscriptions upon old tombstones of the Delabole slate remain remarkably perfect, showing its durability when exposed to atmospheric influences. These slates are shipped at Tintagel and at Boscastle.

There are other slate quarries near Boscastle and near Launceston; and also in Devonshire, at Tavistock, near Plymouth, and at Kingsbridge. (*See Mineral Statistics for 1858.*)

In addition to the true cleaved slates other rocks possessing a fissile structure are used for the purposes of roofing, and therefore pass under the general name of "slates." Thus, the Stonesfield and Collyweston slates are limestones easily split along the planes of bedding. Examples of these will be found in the Hall (*see p. 39*).

#### SANDSTONES.—*Cubes in Table Cases IV., V., and VI.*

A sandstone consists essentially of small siliceous grains cemented together into a solid rock. The nature of the cementing material is important, inasmuch as it determines to a large extent the durability of the stone; those varieties being most durable in which the cement is siliceous. In many sandstones the grains of silica are accompanied by small fragments of other minerals, such as felspar and mica, thus giving rise to varieties known as *felspathic sandstone*, *micaceous sandstone*, &c. The formation of sandstone generally is instructively illustrated by a specimen of recently-consolidated sand from Newquay, in Cornwall, and many similar examples exist around our western coasts, where hills of blown sand prevail. The water percolating through the upper layers dissolves the carbonates of lime, and of iron, which are re-deposited as cementing materials, on the evaporation of the water as it filters through the lower strata of the porous sand.

In texture and colour sandstones are subject to considerable variation, according to the size of the grains and the nature of the cement: the red, brown, and yellow colours exhibited by many sandstones are due to the presence of peroxide of iron, either in an anhydrous or in a hydrated condition.

Sandstones have always been favourite materials with the architect, and an extensive variety of specimens is therefore exhibited. Special description is, however, unnecessary, since every specimen is distinctly labelled, not only with the locality, but in most cases with the names of the buildings in which it is employed; thus rendering the collection highly instructive. This remark equally applies to the other building stones in the Museum.

Among the sandstones are exhibited several specimens of *Millstone Grit*. This is the name given to a series of sandstones interposed, in certain districts, between the Carboniferous Limestone and the Coal Measures. In the north of England, where the grit is typically developed, it occurs as a coarse sandstone, in which the quartz frequently appears as large pebbles, sometimes even reaching

the size of an egg. From the position of the millstone grit, immediately beneath the true coal-bearing rocks, it is not inappropriately called by the miners in some of our south-western coal fields, the "Farewell Rock."

LIMESTONES.—*Cubes in Table Cases V. and VI. Copy of the Farnese Hercules in Portland Stone, No. 72.*

Limestones of several characters, from widely different localities, are here gathered together. Most of these are derived from liassic and oolitic rocks, since palæozoic limestones are, for the most part, sufficiently indurated and compact to receive a polish, and may therefore be classed as marbles rather than as ordinary limestones; whilst on the other hand, the limestones of the upper cretaceous beds are usually too soft for building purposes; chalk, however, is employed in some districts to a considerable extent.

The *Lias* formation, as it is called,—the term being probably a corruption from *layers*, as indicating the mode of occurrence of its beds—extends over a great length of England, stretching in a north-easterly direction from near Lyme Regis, on the Dorsetshire coast, to Redcar, on the coast of Yorkshire. The lias limestones—which are often of a blue tint—are usually more or less argillaceous, and form, when burnt, a valuable hydraulic cement: whilst the finer stones are used not only as building materials, but also as paving slabs. Some of the lias limestones strongly resemble those employed for lithography; the true lithographic stones are obtained from the oolites of Solenhofen, in the Bavarian Jura, a short distance from Munich.

Immediately succeeding the lias is the great group of *Oolitic* rocks which traverse England from the coast of Yorkshire to that of Dorsetshire, in many places affording enormous quantities of excellent building material.

The name "oolite" (*ωδν, ὄον*, an egg; *λίθος, lithos*, a stone), is derived from the limestones of this group, being, for the most part, made up of small egg or roe-shaped particles, which are spheroidal concretions of carbonate of lime; each grain usually presenting a concentric structure, and enclosing a particle of sand, or some other substance which has served as a nucleus. It should, however, be remembered that all the limestones belonging to the oolite-series do not present this peculiar texture; nor, on the contrary, is such oolitic structure confined to rocks of this formation, many of the palæozoic limestones in certain districts being lithologically true oolites.

The lowest division of the oolitic series, known as the *Inferior Oolite*, yields some excellent building stones which are extensively worked in the neighbourhood of Cheltenham. The Painswick stone, for example, comes from this series, and is of extremely fine quality.

It has been shown by Mr. J. W. Judd, that the rock which is known as the Lincolnshire limestone, and was formerly referred to the Great Oolite, should properly be regarded as a member of the Inferior Oolite. The Ancaster, Barnack, and Ketton stones form valuable materials for architectural purposes, and are quarried in this part of the geological series.

From the *Great Oolite*, which occupies a higher geological position than that of the Inferior Oolite, the celebrated *Bath stone* is obtained. The principal quarries of this stone are those of Box, Coombe Down, Monckton, Farleigh, and Corsham Down. In the restoration of Henry the Seventh's Chapel, the Coombe Down stone was employed, costing about 40,000*l.*

Bath stone possesses an agreeable warm tint, is worked with great ease, and may be obtained in blocks of large size; but unfortunately it does not possess great durability when exposed to the atmosphere of large towns. It is, however, extensively employed for ornamental mouldings and sculptured decorations. One peculiarity connected with this and other free-working limestones is that they become in some degree harder on their surfaces by exposure to the weather. This is said to arise from a slight decomposition taking place, which will remove most of the softer particles, and leave the hardest and most durable to act as a protection to the remainder.

The valuable *Portland stone* is derived from the Upper Oolites of the island of Portland, near Weymouth. The quarries from which the stone is obtained,—of which there are at least fifty,—are principally at the north end of the island. The conditions under which the Portland stone, with the overlying Purbeck beds, occurs, will be best understood from the following account of the beds, abstracted from that given by Mr. Webster.

Immediately under the soil is a series of thin beds, about three feet thick, called *slate* by the quarrymen, consisting of limestone of a dull yellowish colour. Below this, is another mass of calcareous stone, of a softer and lighter colour; it is divided into two by a *slaty* bed, the upper being called *ash*, and the lower the *soft burr*. These are between four and five feet thick.

Below this is the *dirt bed*, about one foot thick, which consists of a dark brown substance containing much earthy lignite. In it are found considerable numbers of the fossil trunks of coniferous and cycadeous trees, of which a fine specimen will be found in the N.E. corner of the Hall (No. 53).

A limestone rock, ten feet in thickness, then occurs, which is called the *top cap*, and below that another, distinguished by its cellular character, and known as the *school cap*, which is about three feet thick. Under the school cap is a layer six inches thick of flint or *chert*.

The bed below this is the first which is worked for freestone, and is called *roach*. Its thickness is variable, being in the mean about fifteen feet. This is the most valuable bed, and blocks of a vast size are raised from it for the London market. Below the *roach* is the *rubbly bed*, which is not of much commercial value; this is about five feet thick, and underneath it another good bed of freestone, about six feet on the average in thickness, called the *white bed*, or *best bed*. This lower bed is worked whenever it is found in convenient situations.

Previously to 1623 this stone does not appear to have attracted any attention. From 1660 it has gradually grown into use. Inigo Jones restored a portion of Old St. Paul's, "casing great part of the outside, and adding a grand Corinthian portico to the west front, all of Portland stone." St. Paul's Cathedral, and many of the churches and other large buildings erected in the reign of Queen Anne, were constructed with stone very superior to that now generally employed, as far as regards durability. The quarries from which Sir Christopher Wren obtained the Portland stone which he employed have been long deserted, the only reason assigned being that the merchants find that they cannot sell that stone on account of its being a little harder, and thereby more expensive to work.

No. 47, placed under Case IX., is a large fossiliferous slab of Portland stone from Tisbury, in Wiltshire; and a fine specimen of *Ammonites giganteus*, No. 73, a characteristic fossil of these beds, will be found at the base of the statue of Hercules (No. 72).

Overlying the Portland series are the fresh-water beds of the Pur-

beck group, so called from the district known as the Isle of Purbeck in Dorsetshire, where this formation is well exhibited. From the upper beds of this group is obtained a compact shelly fresh-water limestone known as *Purbeck marble*, of which a specimen is exhibited in Case I. The marble abounds in organic remains, and indeed is a congeries of fresh-water snail shells (*Paludina*), intermixed with the shells of some minute crustaceans. It occurs in beds which vary in thickness from six to nine inches, and it was much employed formerly in this country for making the slender shafts in Gothic churches; but the introduction of foreign marbles has occasioned its use to be almost discontinued.

Very similar to this Purbeck marble are the fresh-water limestones occurring in thin local bands in the Weald clay, and known as *Petworth* or *Sussex marble*. They abound in casts of *paludina*, but of a species different from that which characterizes the Purbeck limestones.

The *Kentish rag*, of which a specimen is exhibited in Case VI., from the Ignanodon Quarry, near Maidstone, is a hard siliceous limestone from the Hythe beds of the lower greensand, where it occurs associated with a soft calcareous sandstone known locally as "has-sock." The rag stone is extensively used for building purposes, the total quantity shipped being about 55,000 tons per annum.

Although British building stones alone are, as a rule, admitted into the collection, an exception is made in favour of the celebrated *Caen stone*, a cube of which is placed in Case V. This Norman oolite, which is an equivalent of our Bath stone, was held in high repute by the architects of the middle ages, and was largely employed in this country. Amongst the buildings in which it was used may be specially noticed the Temple Church, and Winchester and Canterbury Cathedrals.

Before leaving the group of limestones, attention should be drawn to the varieties of this rock, which exhibit a fissile structure and are thus capable of being split into slabs sufficiently thin to be used for roofing purposes. These "slates" were largely employed by Gothic architects, and are still used in ecclesiastical architecture, though generally superseded for domestic purposes by the highly cleavable Welsh slates. The principal fissile limestones are the *Stonesfield slate*, which occurs at the base of the Great Oolite in Oxfordshire, and the *Collyweston slates* which are found in the lower beds of the Lincolnshire Oolite, in Rutland: specimens of both kinds of slate, with the tools used in working them, are exhibited in the Hall. The Collyweston slates are fully described by Mr. J. W. Judd in his "Memoir on the Geology of Rutland," 1875.

DOLOMITES. MAGNESIAN LIMESTONES.—*The stone employed in the building. Antinous as Bacchus, No. 61, eastern side of Hall. Cubes in Case VI. The Giustiniani Minerva, No. 85.*

The Dolomites,—so called because they were first examined by the French geologist, Dolomieu,—are essentially limestones in which the carbonate of lime is replaced to a greater or less extent by carbonate of magnesia. These magnesian limestones are largely developed in the Upper Permian beds of the north-east of England, where they often exhibit peculiar concretionary structures, of which examples will be found in the collection of rock specimens in the upper gallery. As building materials the magnesian limestones are highly important, well selected varieties being exceedingly durable, especially when presenting a crystalline texture, and containing the carbonates of lime and magnesia in nearly equivalent proportions.

The more important quarries from which the magnesian limestone is obtained are those of Anston, of Brodsworth, Cadeby, and Park Nook, near Doncaster, of Huddlestone near Sherburne, and of Smawsee near Tadcaster, in Yorkshire; while in Derbyshire the same stone of fine quality is obtained at Bolsover near Chesterfield, and in Nottinghamshire at Mansfield Woodhouse. An analysis of Bolsover stone gave :

Carbonate of lime	-	-	-	51.1
Carbonate of magnesia	-	-	-	40.2
Oxide of iron and alumina	-	-	-	1.8
Silica	-	-	-	3.6
Water and loss	-	-	-	3.3
				<hr/>
				100.0

The specific gravity of a dry mass of this stone is 2.316. The weight, in the ordinary state, of a cube of two-inch sides, 4890.8 grains; the weight of the same stone when well dried, 4881.4 grains; when saturated with water it weighed 5,042 grains. This is an important consideration in the selection of any building stone. One specimen from Cadeby absorbed one-fourth of its bulk of water. A stone absorbing much water is liable to disintegration, when, during frost, this fluid consolidates. M. Brard introduced an experiment for determining the effect of frost on stones, which was highly recommended in France. The exact mode of experimentalising is to dip measured samples of stone into a boiling solution of Glauber's salts, and leave them in it exactly half an hour. They are then removed and hung up, each by itself, over a vessel containing some of the above cold saturated solution. Within 24 hours a white efflorescence will appear on the surface. The stones must then be immersed in the liquor in the subjacent vessel, so that the crystals disappear. Whenever the efflorescence forms, the stone is to be thus treated. It is said that the tendency to disintegration in any stone will be shown by this treatment. By such an experiment, continued for eight days, the Bolsover stone disintegrated to the extent of one grain and a half. It was however, shown by the late Mr. C. H. Smith that this process differs materially from the action of frost, which it is intended to imitate, since the crystallization of Glauber's salt is unaccompanied by that expansion which attends the freezing of water; indeed, many highly durable stones disintegrated under this treatment to a much greater extent than other stones well known to decay rapidly on exposure.

In some of the chemical works on the Tyne the dolomites of the northern counties are used for the production of carbonate of magnesia; while the magnesian limestones of Marsden are taken in considerable quantities to Sunderland, where, being treated with sulphuric acid the magnesia is dissolved out, and from the liquor obtained, Epsom salt (*sulphate of magnesia*) readily crystallises. A considerable proportion of the Epsom salts now sold is thus obtained.

#### GRINDING AND POLISHING STONES.—Case VIII.

There are tolerably numerous varieties of materials which are used for the purpose of giving fine edges to cutting instruments, or a polish to metal and other surfaces. The collection in this case, mostly presented by the late Mr. R. Knight, is intended to illustrate this class.

*Newcastle grindstones* are very celebrated; it is proverbially said they are found everywhere. They are formed from sandstones which abound in the coal districts of Northumberland, Durham, Yorkshire, and Derbyshire. According to the various degrees of density and coarseness they are employed, especially in Birmingham and Sheffield; for grinding or for giving a smooth and polished surface to their different wares.

At Bilston, in Staffordshire, is found lying above the coal a peculiar sandstone, finer than the above, and of a very sharp nature. This is quarried entirely for the *Bilston grindstones*, which are of great excellence.

The *carpenter's millstone* is a hard and close variety of the Yorkshire sandstone. The northern counties yield several varieties of grindstones, which are much in request for different descriptions of work. *Yorkshire grit*, for example, is used for polishing marble and the copper plates for engravers. The *Sheffield grindstone* is a hard and coarse stone used for common purposes; it is found at Hardsley, 14 miles north of Sheffield. The *Sheffield blue stone* is a fine-grained stone, used for finishing fine goods. The act of grinding on a blue stone is termed "*whittening*"—the Sheffield whittle from the earliest periods being in all probability ground on this stone. *Wickersley stones* are obtained about nine miles from Sheffield, and are much used by the cutlers for grinding.

*Devonshire bats* are in much repute. These are porous fine-grained sandstones found in the quarries of Black Down Cliff, near Collumpton.

**HONE SLATES.**—These are slaty stones used in straight pieces for sharpening tools after they have been ground on revolving grindstones. The more important varieties are the following:—

The *Norway ragstone*, which is the coarsest variety of the hone slates, is imported in large quantities from Norway. In Charnwood Forest, near Mount Sorrel, in Leicestershire, particularly from the Whittle Hill quarry, is obtained the *Charnley Forest stone*, said to be one of the best substitutes for the Turkey oilstone, and it is much in request by joiners and others. *Ayr stone*, *snake stone*, and *Scotch stone* are used especially for polishing copper plates. The *Welsh oilstone* is almost in equal repute with the Charnley Forest stone; it is obtained from the vicinity of Llyn Idwal, near Snowdon, and hence it is sometimes called *Idwal stone*. From Snowdon is also obtained the *cutler's green stone*. The *Devonshire oilstones*, obtained near Tavistock, which were introduced by Mr. John Taylor, are of excellent quality, but the supply of them being irregular, they have fallen into disuse.

The *German razor hone* has been long celebrated. It is obtained from the slate mountains in the neighbourhood of Ratisbon, where it occurs in the form of a yellow vein running through the blue slate, varying in thickness from one to eighteen inches. When quarried it is sawn into thin slabs, and these are generally cemented to slices of slate which serve as a support. Sometimes, however, the yellow and the blue slate are cut out naturally combined. There are several other hone stones, which, however, require no particular notice.

The *Turkey oilstone* is said to surpass in its way every other known substance, and it possesses in an eminent degree the property of abrading the hardest steel: it is, at the same time, of so compact and close a nature as to resist the pressure necessary for sharpening a graver, or any instrument of that description. There

are white and black varieties of the Turkey oilstone, the black being the harder, and it is imported in somewhat larger pieces than the white; they are found in the interior of Asia Minor, and brought down to Smyrna for sale.

Among the examples of mineral substances employed as burnishers will be found a specimen of *agate* (p. 133), and a piece of *hematite* or *red iron ore* (p. 108); the latter mineral, although exhibited under the name of *blood stone*, is to be carefully distinguished from the "blood stone" of the jeweller (*heliotrope*), which is a jaspery variety of silica to be subsequently noticed (p. 133).

The *corundum* and *emery* exhibited in this case are varieties of *alumina*, a mineral which is presented in its purest form in the ruby and sapphire: and which will again be met with the horse-shoe case on the principal floor (p. 134).

Emery is obtained from Cape Emery, in the island of Naxos, and from several localities in Asia Minor; it occurs also in Jersey and Guernsey, in Poland, Saxony, Sweden, and Persia, and some large discoveries have lately been made in Chester, Massachusetts. From its excessive hardness it is used for polishing, for which purpose it is prepared by grinding and elutriation, and then sold under the name of *flour of emery*. The hardness of the Indian sapphire being considered as 100, that of corundum is 77, and that of the emery of Naxos, 46.

In addition to those polishing stones which have been especially mentioned, there will be found on the opposite side of the case a series from France. The celebrated "*Burr Stones*" of La Ferté-sous-Jouarre (Seine et Marne) are unequalled for grist mills. The combined roughness and hardness of this tertiary quartz deposit give it immense advantages, expensive though those stones are, in consequence of the necessity of carefully piecing them together.

The trachytic lava from the extinct volcanos of the Lower Eifel furnishes millstones which have long been justly celebrated. They were well known to the Romans, and are still extensively quarried at Niedermendig, near Andernach, whence they are sent down the Rhine to Holland, and exported to most parts of the globe. Under the name of "*Dutch Blue Stones*" they were formerly much used in this country.

From Milan, in the Grecian Archipelago, are exhibited some trachytic millstones, which are not only extensively used in Greece, but are also largely exported to Turkey and Trieste.

In the same case are several varieties of the hone slates from Cornwall, but the hones from the Cornish slates have not, as yet, come into anything like general use.

The *Talacre scythe stones* are formed from the millstone grit of the Flintshire coal-field, on the estate of Sir Pyers Mostyn, Bart. From Gronant, near Talacre, is exhibited in Case VII. a specimen of *chert*, which occurs in the Mountain Limestone, and is almost exclusively employed in the Staffordshire Potteries for grinding flints.

An artificial grindstone and an emery wheel, prepared by Mr. Ransome's process, are exhibited in this case. They are said to be more uniform in texture and to have a sharper cut than grindstones of natural materials. The preparation of the artificial stone, of which the material of these grindstones is but a modification, will be explained at p. 45.

GYPSUM. PLASTER OF PARIS. CEMENTS.—*Case IX. Cast of bust of Prof. Jukes, 64; of Apollo Belvedere, 120; of Dying Gladiator, 163; of Greek Vase, 11; and of Armour, 40. Pavement in Keene's Cement, 78. Benson and Logan's Cement, 104. Septaria, 62, 126; and in Case VII.*

The well-known mineral *Gypsum* is a hydrous sulphate of lime occurring abundantly in the New Red or Keuper Marls, often associated with rock salt. When transparent and crystallized, it is known as *selenite*, and when fibrous, as *satin spar*; specimens of both varieties will be found in this case. The fine semi-crystalline form of gypsum termed *Alabaster* has been already noticed as an ornamental stone (p. 34). All these substances are natural hydrates; but the mineral called *Anhydrite*, of which a specimen is exhibited from Derbyshire, is a pure sulphate of lime, destitute of any essential water, its composition being, lime, 41·18; sulphuric acid, 51·82.

When gypsum is calcined at a moderate temperature it parts with the whole of its water, and has then a composition resembling that of anhydrite. This calcined gypsum when reduced to powder forms a well-known *Plaster of Paris*, of which three qualities are exhibited. This name is derived from the circumstance that the mineral from which the plaster is obtained is found in abundance in the tertiary deposits of what is called the Paris basin, especially at Montmartre. Mixed with sufficient water to convert it into a paste gypsum eagerly absorbs the liquid, and returning to its original hydrated condition, rapidly solidifies or *sets*. If, however, the gypsum be overburnt this setting is prevented, and in practice to ensure rapid consolidation, it is often desirable not to expel the whole of the water from the mineral. A certain amount of impurity in the original gypsum appears to operate favourably rather than otherwise, the superiority of the French plaster of Paris, which acquires a greater degree of solidity than any other, being referred to its containing about 12 per cent. of carbonate of lime. M. Gay Lussac says that the purest plasters are those which harden least; he does not, however, consider this to depend upon the presence of the carbonate of lime, but on the original hardness of the stone.

The aggregate annual consumption of gypsum in this country has been estimated at 30,000 tons, valued at 10,000*l*. The largest quantities of plaster of Paris are used in the Potteries, the potters employing it to form their moulds.

The facility with which, by means of plaster of Paris, copies of any objects can be obtained, renders it of great value in multiplying the finest works of ancient and modern art. Some extraordinary applications are shown in the copy of a cup by Benvenuto Cellini in the case, and by fac-similes of ancient armour, No. 40, which are hung upon the wall against the eastern staircase. The colour in these examples is given by rubbing bronze powder over the surface of the dry plaster.

One interesting process is shown in which the gypsum is heated to expel nearly all the water; it is then tinted with colour, and subsequently re-saturated with water.

*Ficula ivory*, of which there are several examples, is plaster of Paris, which, after drying, has been made to absorb melted spermaceti by capillary action; or it may be prepared according to Mr. Franchi's process as follows:—Plaster and colouring matter are employed in the proportions of a pound of superfine plaster of Paris to half an ounce of Italian yellow ochre. They are intimately mixed by passing them through a fine silk sieve, and a plaster cast is made

in the usual way. It is first allowed to dry in the open air, and is then carefully heated in an oven; the plaster cast, when thoroughly dry, is soaked for a quarter of an hour in a bath containing equal parts of white wax, spermaceti, and stearine, heated just a little beyond the melting point. The cast on removal is set on edge, that the superfluous composition may drain off, and, before it cools, the surface is brushed, with a brush like that known by house painters as a sash tool, to remove any wax which may have settled in the crevices; and finally, when the plaster is quite cold, its surface is polished by rubbing it with a tuft of cotton wool.

Some casts, as will be seen, are in very high relief; these are made in elastic moulds,—a composition of glue and treacle, which admits of being turned out from the “under cutting” without injury. This process enables any one to copy and preserve the gems of ancient and modern art in a material which is at once pleasing and moderately durable. Ancient ivories can be exactly imitated by the introduction of a little more colour, or by painting the plaster in water-colours before it is dipped into the composition.

By subjecting plaster of Paris to certain methods of chemical treatment, it may be hardened to a considerable extent, and thus becoming much less liable to injury, its value as a cement is greatly increased. Many of these processes of hardening are illustrated in the collection.

*Keene's Cement*, according to the specification, is thus prepared:—Dissolving one pound of alum in a gallon of water, this solution is used for soaking 84 pounds of gypsum calcined, in small lumps. These lumps are then exposed for eight days to the air, and afterwards calcined at a dull red heat.

They are then ground and sifted. The fine powder thus produced is mixed with water into a paste, which may be employed as ordinary plaster of Paris; upon setting, it forms a body of great compactness and durability, which can be polished or coloured without difficulty. If half a pound of proto-sulphate of iron (the common copperas) be added to the solution of alum, the resulting paste has a fine cream colour, and the hardened mass is said to resist the action of the atmosphere.

Among the specimens in this case will be found a series illustrating Mr. Wood's application of blast-furnace slag in forming cement and mortar. The slag is run from the furnace into cold water whereby it is granulated, and this “slag sand” is then mixed with lime.

The *Parian cement* is prepared by soaking the plaster in a solution of borax instead of one of alum. This is exemplified in the cast of the “Dying Gladiator” and its base (No. 163), as well as in the coloured cement on the stairs, in which Derbyshire marbles, to be found in the collection, are imitated, for the purpose of showing to what extent the realization of a natural stone can be secured in an artificial one. *Martin's cement* is formed by combining pearl ashes (bi-carbonate of potash), and alum with the plaster, hydrochloric acid being sometimes added to prevent an alkaline re-action.

*Scagliola* differs from all these cements, in consisting of small fragments of marble, and other ornamental substances, embedded in a base formed of a mixture of plaster of Paris and glue. This was the invention of Guido del Conte, an ingenious mason of Cari, near Corregio, in Lombardy. Scagliola was much employed by the Florentines in some of their most elaborate works.

*Roman cement* is made from the septaria, or “turtle stones,” which occur abundantly in many beds of clay. Great quantities of

these cement-stones are at present procured by dredging off the coast of Hampshire for the septaria which have been derived from the Barton clay. They are also found largely at Harwich and in the Isle of Sheppey, and are dredged up in Chichester harbour, where the yare derived from the London clay. Some typical specimens are exhibited in Case VII.

A *septarium* is simply a nodule of argillaceous limestone, often containing in its interior an organic substance, serving as a nucleus around which the limestone aggregated. The contraction suffered during desiccation has produced fissures, or cracks, which have subsequently been filled by deposition of carbonate of lime. These veins of calcite being disposed with tolerable regularity through a darker base, produce, on section, a peculiar pattern, which is well seen in the polished slab (No. 62).

The cement-stones are calcined in kilns, then ground, sifted, and packed in casks. The cement so prepared possesses the valuable property of rapidly hardening under water, a property which appears to be due to the presence in the septaria of certain adventitious ingredients, especially silicate of alumina and iron. The following may be taken as an average analysis of the English cement-stones yielding this hydraulic mortar:—

Carbonate of lime, 65·7; protoxide of iron, 6·0; silica, 18·0; alumina, 6·6.

*Benson and Logan's metallic cement* is a compound of the ground slag from the copper-smelting works at Swansea with ordinary cement-stone. A sketch painted in colours on a ground of this peculiar cement will be found on the western wall (No. 104). Near this is placed a stereo-chromatic painting on baked clay (No. 114), illustrating the application of alkaline silicates to the fixing of colours on exterior walls. The clay, or other substance serving as the painting ground, is prepared by impregnation with a solution of an alkaline silicate, or "*water glass*," and a surface is thus obtained, to which the colours readily adhere. The painting, which may be executed with perfect freedom unlike the ordinary mode of fresco painting, is finally fixed by a coating of water-glass, which effectually preserves it from the action of weather, even in the most exposed situations. The specimen before us is by Echter of Munich, after a design by Kaulbach.

In Case VII. will be found some specimens of *artificial stone*, prepared by Mr. Fred. Ransome, of Ipswich. This gentleman has at different times patented several processes for this purpose, but the general principle consists in using water-glass as a cement, by which sand is formed into a compact stone, remarkable for its high cohesive power. By the side of this artificial stone are some specimens of flints which have been acted upon by heated soda in the preparation of the alkaline silicate employed by Mr. Ransome. Ordinary flints are subjected to the action of a strong solution of caustic soda in digesters under steam pressure of from 60 to 80 lbs. to the square inch, and are rapidly dissolved with production of solution of silicate of soda. In 1870 Mr. Ransome effected a great improvement in the manufacture of his artificial stone. He mixes the Farnham stone, or soluble silica with silicate of soda or of potash, lime, sand, alumina, chalk, or other convenient materials; the alkaline silicate is then decomposed, the silica combining with the lime to form an insoluble silicate of lime, and also forming with some of the materials a silicate of alumina, whilst the caustic alkali set free by the decomposition seizes upon the soluble silica of the Farnham stone and forms a fresh silicate, which in turn is

decomposed by more lime. The new material which has been called *Apo-nile*, is exhibited in this case, and its application is further illustrated by the large vase on the staircase leading to the principal floor.

TESSELATED PAVEMENTS.—*Centre of Hall. Slabs, Nos. 78 and 96.*

The design of the fine specimen in the centre of the hall has been taken from various tessellated pavements found, during 1793, 1794, and 1795, in the remains of a Roman villa discovered at Woodchester in Gloucestershire. A particular description of this will be found in Samuel Lyson's *Woodchester Antiquities*. Some additional examples of mosaic pavements will be found connected with the specimens of ancient and modern mosaic on the principal floor (p. 165).

The tesserae of which the pavement is formed, and the encaustic tiles by which it is surrounded, were manufactured by Messrs. Minton & Co., of Stoke-upon-Trent. The process of manufacture is an interesting one. Mr. Prosser invented a machine for compressing clay, which has been employed by Messrs. Minton & Co. Porcelain clay, either white or with an admixture of colouring material, is taken in what we may call a dry state, the clay containing only its hygroscopic water; it is placed in moulds the sizes and shapes of the required tesserae or tiles, and, being subjected to pressure, its particles are brought so closely together that they readily cohere, and the whole comes out a solid piece. For the purpose of giving the greatest degree of hardness to it, it is subsequently exposed to heat, when the materials for the formation of the mosaic are ready for use. Another variety of the same manufacture will be seen still nearer the entrance. These pavements are exceedingly durable, and in many situations possess advantages over every other kind of flooring, irrespective of the artistic beauties of which they admit. The tiles are of the same general character; a variety of these will be found with the pottery collection in the upper room.

CRUCIBLES, *Clay and Black Lead. Case X.*

Here will be found examples of the application of clays to the manufacture of melting pots and crucibles. As these vessels have to be exposed to the intense heat of furnaces, it is important that such clays should be selected for their manufacture as are very infusible. Such as contain much potash, lime, or other bases readily fuse into a semi-vitreous mass; but, on the contrary, those which contain a large proportion of silica are highly refractory. To diminish the contraction and expansion which clays undergo on exposure to sudden changes of temperature, as also to increase their infusibility so that collapse of the crucible may be prevented, the clays are generally mixed with certain infusible materials, such as free silica in the form of sand, ground fragments of old crucibles, and finally powdered coke or graphite.

The chief commercial varieties of crucibles are represented in this case, the greater portion having been acquired from the Great Exhibition of 1851.

With the crucibles is exhibited a collection of *fire bricks*, among which may be specially noticed the valuable *Dinas brick*, formed of a highly siliceous rock occurring in the Vale of Neath in Glamorganshire, and known locally as "*Dinas clay*." The powdered rock, mixed with a small proportion of lime to act as a flux, is moulded

into bricks, which are highly refractory, and are hence largely employed for lining copper-smelting furnaces.

The case also contains fire-bricks manufactured from the coal-measure clays and shales of Staffordshire and Scotland, such as the Stourbridge, Garnkirk, and Glenboig fire-bricks.

*BASALT.—Columns from the Giant's Causeway, No. 176.*

These specimens well illustrate the peculiar columnar structure which basalt very frequently assumes, and on which depends the characteristic scenery of the Giant's Causeway, the Isle of Staffa, and other well-known basaltic districts. The basalt of which these are composed is a dark-coloured, fine-grained, igneous rock, composed of an intimate mixture of felspar, usually labradorite, and augite, often associated with certain adventitious minerals, as olivine, magnetic iron, &c. The columns, as seen by the specimens exhibited, are large six-sided pillars, each prism being usually terminated by a convex face at one end, and a corresponding convexity at the other; and by a kind of ball-and-socket joint thus formed, the individual columns are articulated.

The columnar structure of the basalt has been artificially produced. Mr. Gregory Watt melted seven hundredweight of basalt, and kept it in a furnace several days after the fire was reduced. It fused into a dark-coloured vitreous mass with less heat than was necessary to melt pig iron. As refrigeration proceeded the mass became stony, and globules appeared; these enlarged till they pressed laterally against each other, and became converted into polygonal prisms.

In Case VII. are some examples of the application of a basaltic rock, after it has undergone fusion, to decorative and ornamental purposes. Messrs. Chance, Brothers, of Birmingham, adopted the process of melting the Rowley rag, a basaltic rock forming the plateau of the Rowley hills, near Dudley, South Staffordshire, and then casting it into moulds for architectural ornaments, tiles for pavements, &c. Not only the Rowley rag, but greenstone, whinstone, or any similar rock may be used. The material is melted in a reverberatory furnace, and when in a sufficiently fluid state is poured into moulds of sand encased in iron boxes, these moulds having been previously raised to a red heat in ovens suitable for the purpose. The object to be obtained by heating the moulds previous to their reception of the liquid material is to retard the rate of cooling; as the result of slow cooling is a hard, strong, and stony substance, closely resembling the natural stone, while the result of rapid cooling is a dark brittle glass, similar to obsidian.

*LARGE MASS OF NATIVE COPPER from the Mine at the Ghostcroft, Mullion, Cornwall, No. 175.*

Trenance mine, from which this remarkable specimen was obtained, was worked near Mullion, close upon the junction of the serpentine with the hornblende-slate rocks.

It is not unusual to find, in the fissures of the serpentine rocks, masses of native copper; these have frequently induced a further search for mineral treasure, which has rarely been successful. In Trenance mine numerous deposits of a similar character to the specimen exhibited were found, and, consequently, it was hoped that a profitable copper mine might have been opened out; this hope was, however, not realised, and the mine was abandoned many years since. The specimen, which was presented by

the adventurers, is only a portion of the mass as it occurred in nature; the miners being compelled to break it to raise it to the surface.

PART OF A LEAD VEIN OR LODGE FROM THE GRASSINGTON MINES.  
No. 179.

The Grassington mines, the property of the Duke of Devonshire, by whom this fine specimen was presented, are the most important in Yorkshire. This example shows in a very instructive manner the mode in which, ordinarily, lead occurs in nature. By looking at the transverse section, which hangs upon the north side of the stand supporting it, it will be seen that the strata in which this lode occurs have been dislocated—that the beds have lost their regularity; the result of this being a fissure running nearly vertical through all the beds. In this crack the mineral deposit has taken place. The mineral here formed is the sulphide of lead, or galena (p. 106). The regularity observed in the order in which this fissure has been filled in with the mineral matter points to a process in nature analogous to that of the electrotypes in art; but it would be hasty to conclude, without more evidence than experiment has at present given us, that mineral lodes were entirely due to the exercise of electrical force. Further remarks upon this point will be found in connexion with the principal collection of lode specimens at p. 97. The produce of the Grassington lead mines for the year 1874 was 1,311 tons 19 cwt. of ore, producing 823 tons 8 cwt. of lead, with 500 ozs. of silver.

COPPER ORE FROM SOUTH AUSTRALIA. No. 174.

This large specimen, which was presented by the Honourable J. Baker, exhibits a superficial coat of *malachite*, or green carbonate of copper, encrusting a fine mass of *cuprite*, or red oxide of copper. These minerals are frequently present in the upper part of deposits of copper ore, where atmospheric action has penetrated. The specimen before us was obtained from the shallow workings of the Great Northern Copper Mining Company of South Australia, situated 200 miles north of the famous Burra Burra mine. At present the principal copper mines of South Australia are worked on Yorke Peninsula, at the head of Spencer Gulf.

APATITE FROM CANADA. No. 168.

Some of the most ancient rocks known to the geologist occur in the dominion of Canada, and from their development in the Laurentide Hills, north of the River St. Lawrence, have received the name of the *Laurentian series*. This system of rocks is divided into two groups, the lower of which contains thick beds of crystalline limestone, and it is in this limestone that the mineral called *apatite* occurs. Apatite is a phosphate of lime, associated with more or less chloride or fluoride of calcium. The Canadian mineral frequently presents a sea-green colour and a crystalline texture, as seen in the block before us, which was presented by Messrs. Pickford, Winkfield, and Co. This specimen exhibits the apatite in association with a variety of mica known to mineralogists as *phlogopite*. The Canadian apatite is most abundant in the townships of Burgess and Elmsley; the present specimen was obtained from North Burgess Mine, Perth. In some localities it is so abundant as to form irregularly-bedded deposits several feet in thickness. The mineral has a high economic value, and workings have been commenced on

some of the Canadian deposits. By treatment with sulphuric acid it is converted into a soluble superphosphate, which is highly prized by the agriculturist as a fertilizing agent.

By the side of the Canadian phosphate is a fine sample of *phosphorite* (No. 169), or impure phosphate of lime, from Staffel near Limburg, on the Lahn; presented by Messrs. John Taylor and Sons. This mineral is treated in the same way, and applied to the same purpose, as the Canadian apatite.

PORTION OF A VEIN OF GOLD-BEARING QUARTZ. No. 113.

The discovery of gold in California, in June 1848, produced an extraordinary amount of excitement in this country and in the United States; within six months 5,000 persons were attracted to this remote region. The gold from the deposits in the beds of the tributaries running into the Sacramento, and in the alluvial valleys of the country, becoming, from the eager search which was made for it, unequal to the desires of the adventurers, the quartz lodes, which were discovered in the rocks, became the objects of exploration. Numerous mines were opened, and workings commenced upon an extended scale. In the quartz-veins gold is found, and sometimes in considerable quantities; but it is exceedingly uncertain. The specimen exhibited is from the Grass valley, Nevada county, and was presented by the late Mr. F. Catherwood: it fairly represents all the average conditions of the gold-bearing quartz-lodes, not only of California, but of Australia and other countries. Small particles of gold are here and there visible, and some gold is disseminated through the mass, but so finely divided as to be invisible. Some richer fragments of gold-quartz are in the same case. (*See Lectures on Gold, delivered at the Museum of Practical Geology.*)

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## PRINCIPAL FLOOR.

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### THE STAIRCASE.

The following objects are placed on the landing at the head of the first flight of steps leading from the Hall to the Principal Floor:—

*Column of Marble* from Allport, Derbyshire (p. 30).

*Column of Marble* from Allport, supporting a vase in Terra-cotta.

*Column of Shelly Marble* from Stony Middleton, North Derbyshire (p. 30), supporting a vase in Kaolin or China-clay (p. 141).

*Vase* in Ransome's patent artificial stone (p. 46). Presented by Ransome's Patent Stone Company, 1872.

*Column of Encrinital Marble* from Derbyshire (p. 30), supporting a vase similar to that on the opposite side of the last object, but partially coloured.

*Column of Marble* from Monyash, Derbyshire (p. 30).

*Column of Marble* from Nether Haddon, Derbyshire.

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On continuing to ascend the staircase which leads to the Principal Floor the visitor will find the following metal castings on the two sides of the steps:—

*The Dogs of Alcibiades*, cast in iron by Messrs. Moore, Fressange, and Moore.

*A Vase*, in cast-iron, designed by Edington, of Glasgow.

*Candelabrum*, in iron, from the French Exhibition of 1846.

*Candelabra*, in iron, cast by Moore, Fressange, and Moore.

*Nymph and Sea-horse*, cast in iron by M. Durenne.

*Eos*, a favourite greyhound of H.R.H. the late Prince Consort, life size; cast in zinc, in imitation of bronze; the original sculptured by Francis. Cast by Karl Schroder, London. Presented by the *Vieille Montagne Company*.

*Sleeping Dog*, cast in iron by Coalbrookdale Company.

*Diana attiring*, cast in iron by Moore, Fressange, and Moore,

*Venus unrobing*, cast in iron by Moore, Fressunge, and Moore.

The visitor on reaching the principal floor will find, at the head of the staircase, the casting of Venus on his right hand, and that of Diana on his left hand.

The numbering of the cases on this floor commences on the right-hand side, close to the casting of Venus.

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## SYNOPSIS

### OF THE COLLECTION ON THIS FLOOR.

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- BRITISH METALLIFEROUS MINERALS, OR ORES. pp. 79 to 87, and pp. 106 to 110.
- FOREIGN ORES. pp. 87 to 97.
- ILLUSTRATIONS OF MINERAL LODES. pp. 97 to 101.
- COLONIAL MINERALS. pp. 101 to 106.
- NON-METALLIC MINERALS. pp. 121 to 139.
- METALLURGY. pp. 110 to 121.
- In Wall-cases 1 to 14 on **w.** side, embracing, COPPER, 1 to 7; TIN, 8, 9; BISMUTH, COBALT, NICKEL, and WOLFRAM, 9; ZINC, 12; MANGANESE, URANIUM, TITANIUM, VANADIUM, and CHROMIUM, 13; ANTIMONY, GOLD, SILVER, and ARSENIC, 14; and Wall-cases 43 to 56 on **e.** side, embracing LEAD, 43 to 45; and IRON, 46 to 56.
- Wall cases on **w.** side from 15 to 23, embracing COPPER, 15 to 17; IRON, 18, 19; MANGANESE, BISMUTH, MOLYBDENUM, URANIUM, TIN, COBALT, NICKEL and ANTIMONY, 20; ZINC and LEAD, 21; SILVER, 22; GOLD, PLATINUM, MERCURY, and ARSENIC, 23.
- Wall-cases at north end of Museum, on the two sides of Model Room, 24 to 36.
- Wall-cases on **e.** side 37 to 42. AUSTRALIA, 37, 38; EAST INDIES, 38 to 40; Canada, 40 to 42; NOVA SCOTIA, NEW BRUNSWICK, BRITISH COLUMBIA, and WEST INDIES, 41; SOUTH AFRICA, 42.
- N.B.—Australian Gold in Pedestal Case, No. 36 on **w.** side.
- Horse-shoe Case in central area.
- COPPER SMELTING. **w.** side, Table-cases 48 and 49; and Copper Manufacture, Wall-cases, 25, 26, 27, and 28.
- TIN SMELTING. Table-case 48.
- ZINC SMELTING. Table-case 47.
- BRASS, GERMAN SILVER, ARSENIC, COBALT, and NICKEL. Table-case 47.
- LEAD SMELTING. Table-case 52.
- SILVER and MERCURY. Table-case 52.
- IRON and STEEL. Table-cases 50 and 51.
- Many other illustrations properly included in the metallurgical series, will be found in some of the pedestal cases in the central area, namely Nos. 4, 6, 7, 8, 10, 12, 14, 18, 21, 42, 43, 44, and 46.

POTTERY AND PORCELAIN. pp. 140 to 155.	The ceramic series will be found arranged in the embayments on the east and west of the stairs. The descriptions commence with the raw materials in the lower part of case 57 on the right hand or <b>m.</b> side; then proceed with Pedestal-cases 61, 62, 63, 68, and Wall-cases I. to XXXIX. on both sides of the principal floor. Foreign pottery, &c. in the lower gallery on both sides.
GLASS, ANCIENT AND MODERN. pp. 155 to 164.	Cases in the embayment, at the southern end (Nos. 56, 57, 65, 65, 66, 67, and 68). Sheet and crown glass in the gallery on the <b>w.</b> side.
ENAMELS. pp. 164, 165.	Table-cases 60 and 61, and on the <b>m.</b> side; and the model of tomb of William de Valence, No. 59.
MOSAICS. pp. 165, 166.	Table-case 54. Specimens on walls of stairs to galleries.

*Central Cases and Models.*

VASE IN SIBERIAN AVENTURINE (No. 1) opposite entrance from Hall	-	-	-	p. 54
CASE OF RUSSIAN STEEL WORK, &c. (No. 2)	-	-	-	54
GEOLOGICAL MODEL OF LONDON (No. 3)	-	-	-	54
MODEL OF PUYs IN AUVERGNE, (No. 41)	-	-	-	72
CRYSTALLIZED SLAGS (No. 4)	-	-	-	55
CRYSTALLIZED FURNACE-PRODUCTS (No. 42)	-	-	-	73

*East Side, commencing at S. End.*

SOUTH AMERICAN AGATE (No. 5)	-	-	-	p. 56
ORNAMENTAL IRON CASTINGS (No. 6)	-	-	-	56
MANUFACTURE OF SWORDS AND GUNBARRELS (No. 7)	-	-	-	57
ILLUSTRATIONS OF PHYSICAL PROPERTIES OF METALS (No. 8)	-	-	-	58
MANUFACTURE OF SPIEGELEISEN, &c. (No. 10)	-	-	-	59
MODEL OF AUSTRIAN SALT MINE (No. 11)	-	-	-	60
ILLUSTRATIONS OF SWEDISH METALLURGY (No. 12)	-	-	-	60
MODEL OF AUSTRIAN SALT MINE (No. 13)	-	-	-	60
ILLUSTRATIONS OF SWEDISH METALLURGY (No. 14)	-	-	-	60
STONE IMPLEMENTS (No. 15)	-	-	-	61
ILLUSTRATIONS OF THE SUB-WEALDEN EXPLORATION (No. 16)	-	-	-	61
MODEL OF PART OF ISLE OF WIGHT (No. 17)	-	-	-	62
MODEL OF BESSEMER STEEL WORKS (No. 18)	-	-	-	62
VASE IN FLUOR-SPAR (No. 19)	-	-	-	63

*At Northern End.*

SLAB OF BONE-BRECCIA FROM A FRENCH CAVE (No. 20)	-	p. 64
MODEL OF STEEL WORKS AT SHEFFIELD (No. 21)	-	64
WATER BAROMETER (No. 22)	-	65
MODEL OF LEAD-FUME CONDENSER (No. 23)	-	65
MODEL OF CORNISH MINING DISTRICT (No. 24)	-	65

*West Side, commencing at the N. End.*

MODEL SHOWING THE COMSTOCK LODGE AND PROJECTED SUTRO TUNNEL (No. 25)	-	-	p. 65
MODEL OF AUSTRALIAN GOLD WORKINGS (No. 26)	-	-	66
MODEL OF PART OF ALSTON MOOR (No. 27)	-	-	66
MODEL OF LANDSLIP AT AXMOUTH (No. 28)	-	-	67

MODEL OF PEAT MOSS IN LANARKSHIRE (No. 29)	-	-	p. 67
MODEL OF HOLMBUSH MINE, CORNWALL (No. 30)	-	-	68
MODEL OF SURFACE-WORKINGS OF A NEWCASTLE COAL PIT (No. 31)	-	-	68
SPECULAR IRON ORE, FROM ASCENSION (No. 32)	-	-	68
GALENA AND OTHER MINERALS (No. 33)	-	-	69
GEOLOGICAL MODEL OF MONT BLANC (No. 34)	-	-	69
MODEL OF PASS OF MONT CENIS (No. 35)	-	-	69
AUSTRALIAN GOLD (No. 36)	-	-	69
MODEL OF THE ALPS (No. 37)	-	-	70
ELECTRO-METALLURGY (No. 38)	-	-	71
EOZOONAL LIMESTONE (No. 40)	-	-	72
ORNAMENTAL CASTINGS (No. 43)	-	-	74
CHINESE BRONZES (No. 44)	-	-	74
MALACHITE AND AMAZON STONE (No. 45)	-	-	75
METEORITES AND VARIOUS METALS (No. 46)	-	-	75

N.B.—Throughout this Guide-book the numbers of the table-cases are in italics, as *Cases 1, 2*; whilst the wall-cases are indicated by **thick figures**, thus, **21**.

It will be seen, from the preceding synopsis, that the Principal Floor of the Museum contains the mineralogical, the metallurgical, and the ceramic series, associated, however, with various miscellaneous objects. The mineralogical series is separable into two divisions: the metalliferous, containing the ores of our ordinary metals; and the non-metalliferous, or, those minerals which are either entirely destitute of metal or, at most, contain only some of the lighter and rarer metals. The metallic minerals are arranged in the 56 wall-cases around this floor of the Museum (p. 79), whilst the non-metallic minerals are displayed in the large central case which is known from its original shape, as the Horse-shoe case (p. 121). This horse-shoe case surrounds the glass roof of the lecture-theatre below, and forms a prominent object in the centre of the room. The metallurgical series is arranged in the six flat cases in the embayments in front of the British metallic minerals (p. 110), but the space thus allowed being insufficient, the metallurgical specimens have crept into several of the adjacent pedestal cases in the central area. The original intention of those who devised the arrangement—an intention which has been carried out wherever practicable—was to exhibit the ore or raw material in the wall-cases; then to show the treatment to which the ore was subjected, for extraction of metal, in the flat cases immediately in front of the ores; whilst the applications of the metals in the arts would be illustrated by specimens in the pedestal cases in front of the metallurgical collection. Thus the ores of copper are exhibited in Wall-cases **1, 2, 3, 4**, &c.; the metallurgy of copper is represented in the Flat case No. 47 in front of these wall-cases; and finally the casting of copper and its alloys is illustrated by statuettes in the Pedestal-case No. 43, which again is immediately in front of No. 47.

The ceramic and vitreous series is separated as far as possible from the other collections on this floor, and forms a compact group of objects at the southern end of the room (p. 140). In addition, however, to these systematic collections there are exhibited in this gallery a large number of models and miscellaneous objects; and as some of these are likely to arrest the attention of the visitor as soon as he reaches this floor by the stairs leading from the Hall, it may be desirable to commence our survey by describing the objects which will be found in the central area.

## CENTRAL CASES AND MODELS.

No. 1.—VASE OF SIBERIAN AVENTURINE.—*Bequeathed by Sir R. I. Murchison, Bart., K.C.B., F.R.S.*

This handsome vase was presented in 1843 by the late Emperor of Russia, Nicholas I., to Sir R. I. Murchison in recognition of his services in exploring the geology of part of the Russian Empire. The material of the vase is a micaceous quartz-rock, passing into aventurine (p. 132). The flakes of mica are arranged in irregular bands running obliquely across the oviform body of the vase, whilst the whitish colour of the stone is relieved by iron-stained patches, of brown and yellow tints. A mottled pink variety of quartz-rock forms the base of the vase, which is distinct from the body; and the whole is supported on a handsome pedestal of grey porphyritic rock. The materials of both vase and pedestal were obtained from the hills of Bieloretzsk and Korgon, a dependence of the Altai Mountains, and were polished in the Government of Tomsk. The vase is four feet in height, and measures six feet in circumference at its largest part. So great was the difficulty of obtaining blocks of this size, and of polishing such hard materials, that it is believed only one similar vase was ever made; this was presented by the Emperor Nicholas to Baron Humboldt, and is now in the Royal Museum, at Berlin.

No. 2.—RUSSIAN STEEL WORK, &c.—*Bequeathed by Sir R. I. Murchison, Bart., K.C.B., F.R.S.*

A small table-case, standing immediately behind the Siberian vase, contains some interesting objects bequeathed to the Museum by the late Director. One of these is an ornamental steel plateau, or salver, manufactured at Zlataust in the Ural Mountains. This town, which has been called "the Birmingham and Sheffield of the Ural," is situated on the banks of the River Ai, in a romantic valley on the western side of the watershed of the Ural. A view of the locality adorns the centre of the plateau. Under General Anosoff, the Imperial Steel Works of Zlataust attained great celebrity for the manufacture of sword blades. "It may be doubted," said Captain James Abbot, "whether any fabric in the world can compete with that of Zlataust in the production of weapons combining, in an equal degree, edge and elasticity."

The plateau is ornamented with a border representing allegorically the manufacture of a sword, and some examples of the actual swords will be found in Pedestal-case No. 7. The plateau is formed of burnished steel richly ornamented with gilt damascene work, and bears an inscription in Russ, which has been thus translated:—

"To the geologist R. Murchison, in testimony of its particular esteem, the Administration of Mines in Russia, Zlataust, 1843."

Another prominent object in this case is a gold snuff-box, set with a large number of diamonds, and ornamented with an enamel portrait of the Emperor of Russia, Alexander II. This box was presented to Sir R. I. Murchison by the late Emperor Nicholas.

## No. 3.—GEOLOGICAL MODEL OF LONDON.

This large model was constructed by Mr. T. B. Jordan, under the superintendence of Mr. W. Whitaker, of the Geological Survey. It represents a tract of country around the metropolis as a centre, measuring about 15 miles from east to west, and about 11 miles from north to south; or a total area of something like 165 square

miles. The horizontal scale is the same as that of the county maps of the Ordnance Survey, namely six inches to the mile; whilst the vertical scale is 200 feet to the inch, or about 4·4 times as great as the former. Had the vertical scale been the same as the horizontal, as was originally intended, the heights on the model would have been so insignificant, that the highest point which it includes, the top of Hampstead Heath, would have been represented by a rise of little more than half an inch. An exaggerated vertical scale was therefore absolutely necessary in order to exhibit with due effect the undulations of the ground. It will be observed that although the area around the metropolis is popularly known as the "London Basin," this basin is in fact nothing more than an extremely shallow depression; and even with the exaggerated dip represented in the model, the beds slope towards the centre of the trough at a very slight inclination.

The oldest rock which comes to the surface within the area of the model is the chalk; but some of the deep wells sunk in the London basin have reached the underlying rocks. Thus the famous boring at Kentish Town pierced the Chalk, the Upper Greensand, and the Gault; and then entered older rocks the geological age of which is extremely doubtful. The beds below the chalk are seen in section on the sides of the model. In fact the model is constructed in nine separate blocks, five of which can be raised by means of a winch so as to expose the sections on their inner sides.\*

By far the greater part of the country represented in this model is formed of rocks overlying the chalk and belonging to the tertiary series. These consist of the Thanet beds, immediately above the chalk; followed by the Woolwich-and-Reading series, the Oldhaven beds, and the London Clay. This clay is about 400 feet in thickness under the Metropolis, and is covered on the hills of Hampstead and Highgate by sandy beds known as the Bagshot Sands. No deposits of more recent age occur in this area, until we reach the post-tertiary gravels, sands, clays, brickearth, &c., which are grouped together under the general name of Drift. A system of colouring exhibits the distribution of the several formations, including these superficial deposits. For further information the visitor should consult the *Guide to the Geology of London*, written by Mr. Whitaker in explanation of this model and of the Geological-Survey Map of London and its environs.

#### NO. 4.—CASE OF CRYSTALLIZED SLAGS.

A small table-case near the iron casting of Venns, at the head of the staircase, contains an interesting collection of slags, or fusible silicates produced in various metallurgical operations. Many of these, exhibiting beautiful crystalline forms, were examined by Dr. Percy and Professor W. H. Miller, who, in 1846, reported to the British Association the results of their inquiry. The production, under the peculiar circumstances in which these slags were formed, of crystalline compounds, in many respects similar to some which are found in nature as minerals, renders the inquiry into their chemical constitution and physical conditions a peculiarly interesting one; and in its bearings upon many geological phenomena it is most especially so, as showing the influences of the long-continued action of high temperature upon mineral combinations and crystalline structure. Among the specimens may be observed some

\* Visitors desirous of inspecting the sections on the sides of the moveable blocks, should apply to the officers of the Museum for permission to raise them, but should not otherwise attempt to disturb the model.

examples of the curious *hair-like slag* occasionally obtained from blast-furnaces. This is produced by the blast from the tuyers catching the slag, and drawing it out into fine fibres, like spun glass. A similar natural product from the Sandwich Islands is known as "*Pélés hair*," (see p. 136). For information on the contents of this case generally the visitor may consult the first volume of Dr. Percy's *Metallurgy*.

#### No. 5.—AGATE.

A fine polished specimen of agate stands on a pedestal near the model of London. Nearly all the agates which are brought into commerce are obtained from Uruguay, in South America, whence they are exported to Germany, and are cut and polished in the neighbourhood of Oberstein, on the River Nahe, a tributary to the Rhine. The district around Oberstein and Idar has become famous for its agate-works, but the stones themselves are no longer obtained, as they formerly were, from the surrounding hills. (See p. 133.)

#### No. 6.—ORNAMENTAL IRON CASTINGS.

Some fine examples of the use of iron in art manufacture, and for the reproduction, in durable material, of works of high art, are here exhibited. Such productions are coloured either by the application of a resinous paint or by a process of bronzing, which may be effected by the application of *chloride of platinum*, of the *salts of copper and iron*, and by other means, one of these being the deposition of thin coats of copper or brass by the electrottype process.

*Berlin Cast Iron*.—Some beautiful specimens of the delicate iron castings of Prussia are in this case. At the time when the final struggle commenced between Prussia and Napoleon, the patriotism of the Prussian ladies was particularly conspicuous. With the noblest generosity they sent their jewels and trinkets to the Royal Treasury, to assist in furnishing funds for the expenses of the campaign. Rings, crosses, and other ornaments of cast iron were given in return to all who made this sacrifice. They bore the inscription, *Gold für Eisen* (gold for iron). Such Spartan jewels are, to this day, much treasured by the possessors and their families. —(*Handbook of Northern Germany*.) This led to the production of ornaments far more delicate than anything which had heretofore been manufactured; and these becoming known and admired in every part of Europe, an extensive trade in them speedily arose, and has been maintained.

*The Castings intended for use in Bookbinding, the Cast Iron Fan, Necklace, and Bracelets*, from the iron works of the Count de Stolberg-Wernigerode, at Ilsenburg, Hartz Mountains (Magdeburg), are fine examples of this manufacture.

The large circular ornamental casting, with the sand attached, as it was taken from the mould, shows the perfection to which the processes have been brought. It has been thought that much of the beauty of these castings depends upon the sand employed in forming the moulds. Hence the sand collected about this casting has been carefully analysed in the metallurgical laboratory. It was found to consist of—

Silica	-	-	-	79.02
Alumina	-	-	-	13.72
Protoxide of iron	-	-	-	2.40
Lime	-	-	-	trace
Magnesia	-	-	-	0.71
Potash	-	-	-	4.58

*Whitworth's Screws and Plates* may be regarded as perfect examples of the production of true surfaces. When the two iron planes are brought together the upper one floats on a film of air, and when this is pressed out the cohesive force of the two surfaces is very great; this may be regarded as a proof of the correctness with which these surfaces have been formed.

The screws and the gauges were prepared with a view to the introduction of a system of standard screws and gauges.

#### NO. 7.—SWORDS AND GUN-BARRELS.

*Swords.*—The oriental sword blades have always been celebrated, and their superior character has been stated to, and probably does, belong to the very excellent iron ores which are obtained in various parts of Asia, and to the reduction of those ores by charcoal. Swords and daggers from the Punjab, Ispahan, and Borneo are in juxtaposition with specimens of the Damascus, Andrea Ferrara, and Toledo blades.

The finest oriental sabres are those, professedly of great antiquity, presumed to have been made at Damascus in Syria, Ispahan in Persia, and at Cairo in Egypt. The characteristics ascribed to the real Damascus blades are, extraordinary keenness of edge, great flexibility of substance, a singular grain of fleckiness always observable on the surface, and a peculiar musky odour given out by any friction of the blade, either by bending or otherwise.

Milan, Bilboa, and Toledo furnished the Crusaders with their swords, Milan appearing to have been the great mart for the sale of both the Spanish and the Italian weapons.

Toledo under the Romans, and in the time of the Moors, was celebrated for the admirable temper of its swords, "which is chiefly attributable," says a writer on the Toledo blades, "to some favourable quality in the water of the Tagus, used in tempering the steel." The swords manufactured on the banks of the Guadalquivir are said to be very inferior, from this cause, to those made by the same workmen on the banks of the Tagus.

Andrew of Ferrara has associated his name with the swords of his manufacture, "Andrea Ferrara." This sword maker was considered, in his time, to be the only man in Great Britain who knew how to temper a sword in such a way that the point should bend to touch the hilt and spring back again uninjured. He is said to have resided in the Highlands of Scotland, where he employed many men in forging his swords, devoting his entire attention to tempering them. This operation he performed in a dark cellar, the better to enable him to distinguish the colours produced by heat on the blade, upon which everything depended.

Swords appear to have been made at Birmingham from a very early period: Hutton, the local historian, says; long before the landing of Cæsar. Sword making is, however, now one of the staple trades of Birmingham; the forges of Sheffield, however, furnish a large quantity of bars of steel, called *sword moulds*. One of these is shown, as also the fastening of the *tang*, which is of iron; and the results after the different stages of forging. It is hardened by heating it until it becomes *worm red*, and then dipping it, point downwards, in a tub of cold water. It is tempered by drawing it through the fire several times, until it exhibits a bluish oxidation on the surface. It is subsequently polished and mounted.

*Manufacture of Gun-barrels.*—The principal object in the manufacture of a gun-barrel is its strength. It should possess so much

tenacity as will ensure its resisting the sudden shock to which it is exposed in projecting the ball by the explosive force of gunpowder. Experience has proved that this is obtained by the use of iron which has undergone peculiar processes of manufacture. *Scrap iron* is employed for inferior barrels, *horse-shoe nails* and *scrap steel* are taken for superior kinds; these are welded into flat bars; the bars of iron and steel are again welded together, and formed into square bars. If a number of straight bars were welded together to form a barrel, they would be liable to open along the lines of welding; at all events, such a gun-barrel would not be nearly so safe as one made of the same bars formed into a helix, and then welded into a tube. These two conditions are shown in the specimens in the case.

By altering the arrangement of the fibres of the iron, there is produced a different pattern on the surface of the barrel when they are rendered visible by polishing. Thus one bar is twisted to the right, another is twisted to the left hand. Now these when twisted on a mandril are welded into a barrel, which will exhibit an involved pattern. If they are combined, or if an untwisted bar is placed between them, and they are then turned and welded, we have a still more elaborate pattern as the result. Thus the gunsmith possesses the power of varying extensively the patterns upon the barrel.

From the welding-shop the barrel passes to a workman who duly examines its soundness, and, if it is required, straightens it. The barrel is then transferred to the boring mill, and properly ground; it passes through a subsequent process of *fine boring*. The exterior of the barrel is ground by the grindstone, and then filed with a smooth file and finished; those last operations are commonly performed by women. Barrels are browned by the application of a combination of iron and copper in nitric acid, to which either spirits of wine or sweet spirits of nitre have been added.

The lower part of this case is occupied by some very fine examples of Bessemer steel from the International Exhibition of 1862, presented by Mr. Bessemer.

#### No. 8.—ILLUSTRATIONS OF THE PHYSICAL PROPERTIES OF METALS.

A collection of specimens is here exhibited to illustrate the physical properties of metals, especially their malleability and ductility, and to show the advantage which is taken of such properties in applying metals to purposes of ornament. Malleability is the property of permanently extending without fracture when the substance is subjected to pressure, as in rolling, or to impact, as in hammering. The great malleability of copper is well shown by a penny-piece rolled out to a length of ten yards. Excellent illustrations of the malleability of copper are also furnished by Messrs. Tylor's series showing the successive stages in the manufacture of a vase by hammering it into shape from a flat sheet. The large central ewer, of French manufacture, in the style of the Italian renaissance, shows how copper admits of being beaten up; and there are likewise examples of *repoussé* work in silver. Specimens are also exhibited of copper sheathing, rolled zinc, sheet cadmium, "paper iron," gold leaf, and various foils. It is found that in the process of rolling or of hammering, the metal under treatment is apt to lose its malleability and acquire brittleness; in order, therefore, to restore its malleability it is necessary to anneal the metal by exposure to heat.

Ductility, or the property of permanently extending, without rupture, when the substance is subjected to a pulling force, as in wire-drawing, is a property closely connected with malleability. Some examples of gilt silver wire, contributed by Messrs. F. and E. Stanton, are interesting as showing the great extension of which gold and silver are capable. In one example 10 dwts. of metal, consisting of 2 grains of fine gold, covering 238 grains of silver, were drawn to the length of 1.824 yards; the thickness of this silver wire will therefore be 0.0093115 inch, whilst that of the overlying gold will be only 0.0000216 of an inch. Yet, even these limits, striking as they appear, may be exceeded in wire-drawing.

There are also in this case several coins and medals, showing the sharpness with which certain metals receive impressions when stamped. The process of *silver-plating* is likewise illustrated here. The art of overlaying one metal with another of a more valuable character is of great antiquity; but, as far as we can judge, the application of the more expensive metal upon the inferior one was originally merely some method of washing or gilding, or of affixing sheets and foils by means of some adhesive material.

The process of "fire-plating," so called to distinguish it from the electro-plating, appears to have been first employed in the metropolis. The method is as follows:—

An ingot of copper as shown, or of copper containing a little brass, is prepared after casting, by filing a perfectly smooth and clean face, which is afterwards carefully scraped; on this a plate of silver, also perfectly smooth and clean, being a little less in size than the copper, is placed so that the bright surfaces shall be in contact. Over the silver is placed a piece of sheet iron of the same size, brushed over with whiting to prevent its adherence to the mass when heated. The iron, silver, and the copper ingot are bound together by means of small iron binding wire; a little borax ground with water is laid around the silver in the space where its edge approaches that of the copper, after which it is ready for the fire. A perfectly clear coke fire being obtained in a small reverberatory furnace, the mass is placed in it, and allowed to remain until symptoms of fusion appear upon the edges of the silver, it is then immediately withdrawn and allowed to cool. If the right time is secured for withdrawing the copper, the silver will be found to have adhered perfectly over every part, and the mass may be submitted to rolling and the processes of manufacture, the silver uniformly extending with the copper. This is illustrated by the ingot and the sheet in this case. The process of plating steel blades for dessert knives is also shown. For electroplating, see p. 71.

No. 9.—HEAD OF MELPOMENE, *after the antique, electrotyped and presented by Messrs. Elkington & Co.* At foot of eastern staircase to Gallery.

For description of the art of electro-metallurgy, see p. 71.

#### No. 10.—MANUFACTURE OF SPIEGELEISEN, &c.

One half of the table-case near the electrotype of Melpomene is devoted to illustrations of the manufacture of Spiegeleisen, mostly presented by Mr. H. Bauerman. Spiegeleisen is a highly crystalline variety of white cast-iron, rich in carbon and manganese, and exhibiting on fracture brilliant mirror-like cleavage-planes. Of late years its manufacture has acquired considerable importance from its use in the Bessemer process of steel making. When the carbon has

been completely removed from the cast-iron in that process, a proper quantity of spiegeleisen is introduced into the Bessemer convertor, and thus the required proportion of carbon can be added with great precision. The spiegeleisen is largely smelted from the spathic iron ores, or carbonate of iron, of the Siegen district in Westphalia, and is also manufactured from similar ores in Styria; whilst in this country suitable materials are furnished by the spathose ores of the Exmoor hills in Devonshire, the Brendon hills in Somersetshire, and Weardale in Durham. Spiegeleisen is also obtained in some of the Continental works from manganeseiferous hematites, and it is likewise smelted from the residues obtained in the treatment of mixed ores of iron and zinc at Newark in New Jersey. The latter process is well illustrated in the case before us. After the greater part of the zinc has been removed from the ore, the cinder-like residue is smelted for spiegeleisen. This residue contains all the iron and manganese originally present in the Franklinite, one of the chief minerals in the mixed ore. The bright green colour of the slag accompanying the spiegeleisen is due to the presence of manganese. The proportion of manganese in the spiegeleisen varies considerably in different specimens; one example exhibited, from Laibach in Carniola, contains as much as 14 per cent. But even this proportion is far exceeded in the alloy known as *ferro-manganese*, one specimen of which, in the case before us, contains not less than 33 per cent. This alloy is used for the same purposes as spiegeleisen.

On the opposite side of this case will be found a series of specimens illustrating the smelting of the brown iron ores of the Coral Rag—one of the sub-divisions of the series of middle oolites—as carried on at Westbury in Wilts.

A portion of this case is temporarily occupied by specimens showing the powerful agglutinating action of oxide of iron.

Nos. 11 and 13.—MODELS OF THE SALT MINES of *Hallein and Hallstadt, in the Salzburg Alps.*

The mines here represented are opened in deposits of very irregular form belonging to the secondary series, in which the rock salt is mingled with clay and gypsum. The principle of working is to introduce fresh water into excavations prepared for the purpose, where it gradually dissolves the salt, leaving the clay and gypsum behind, the solvent action being exerted chiefly on the roof of the chamber; the brine is then conducted by lower galleries to the outside of the mountain, and runs in pipes to the spot where the evaporation works are situated. A third model, representing the salt mines of Aussee, will be found in the upper gallery.

Nos. 12 and 14.—SWEDISH IRON AND STEEL, COPPER, &c.

It is well known that iron of a very superior quality, much valued for steel manufacture, has long been produced from the iron ores of Sweden. These consist chiefly of the magnetic and red oxides, which are classed together as "mountain ores," to distinguish them from the brown oxides, which occur in the shape of lake and bog-ores, and yield an inferior kind of iron employed chiefly for castings. The mountain-ores are calcined usually in kilns heated by the waste gases from the blast furnace, and are smelted exclusively with charcoal. It is to the employment of this fuel, and to the freedom of the ores from phosphorus, that the Swedish iron owes its superiority. The greater part of the pig iron is converted into malleable iron in refineries, or hearths, heated with charcoal. At

Dannemora the ancient Walloon process is still employed, but at most other works it has been displaced by the so-called "Lancashire method," introduced from South Wales. In some of the Swedish works puddling is practised to a certain extent, and the Bessemer process has also been introduced.

The table-case No. 12 is entirely devoted to specimens of Swedish iron and steel, and a large part of No. 14 also contains examples of these metals and of the ores from which they are produced. But the visitor will also find in No. 14 a number of other Swedish metallurgical products, including a series illustrating the extraction of nickel at Klefva in Småland; the smelting of lead at Sala and the production of copper at Falun. The mines, or rather open workings, at Falun, in Dalecarlia, are of great antiquity, and yield large quantities of copper and iron-pyrites, but the workings are of much less importance now than they were formerly. The ores are but poor, and yield when dressed not more than about 4 per cent. of metal.

#### No. 15.—STONE IMPLEMENTS.

Associated with the bones of many of the extinct mammalia of the post-pleiocene era there have been found within the last few years great numbers of flint implements, bearing undoubted proofs of human workmanship. The French antiquary, M. Boucher de Perthes, was the first to direct attention to the occurrence of flint "hatchets" at considerable depths in the sands and gravels of the valley of the Somme. Some of these worked flints from Abbeville and Amiens are here exhibited, and with them are other flint implements from widely separated localities. These rudely chipped flints, occurring in the drift-gravels, are to be distinguished from the more highly finished *celts*, which, in most cases, bear evidence of having been carefully ground and polished: such stone weapons, by no means always of flint, are much more recent than the worked flints from the drift, being preferable to that pre-historic era, known to archaeologists as the polished or newer stone age. The former are known as *palæolithic*, the latter as *neolithic* forms.

For comparison with these ancient flints and celts, and to explain their probable use, there are exhibited, in the opposite compartment of the case, several examples of the rude stone implements used by certain savage tribes at the present day. A few flint arrow-heads, prepared to deceive collectors, are also placed by the side of the genuine relics.

Those visitors who desire to study in greater detail the relics of the "stone ages" may be referred to the splendid collection bequeathed to the nation by the late Mr. H. Christy, and exhibited under the care of Mr. A. W. Franks, F.R.S., at No. 103, Victoria Street, Westminster.

#### No. 16.—ILLUSTRATIONS OF THE SUB-WEALDEN EXPLORATION.

On the occasion of the meeting of the British Association at Brighton in 1872, a bold geological experiment was projected by Mr. Henry Willett. The experiment consisted in an attempt to ascertain the thickness and the order of succession of the several secondary rocks beneath the Wealden area in Sussex. For some years the notion had had been gaining ground among geologists that these secondary rocks were comparatively thin in the south-east of England, and that some of them might be altogether absent, so that the older or palæozoic rocks would probably be found within a moderate depth. If the palæozoic rocks were thus accessible it was clearly possible

that they might include productive coal-measures, and hence a notion got abroad that this experiment was really a search for coal in Sussex—a notion entirely unsupported by men of science. The site finally selected for the enterprise was in the parish of Netherfield near Battle. After the boring had reached a depth of 1,030 feet some accident led to the abandonment of this hole, and a new boring was commenced with diamond-mounted drills, on an adjacent spot. The second boring, begun in February 1875, attained a depth of nearly 2,000 feet, when it was found necessary to suspend the working for lack of funds. Major Beaumont, M.P., is however, now seeking to resume the boring, and has been supported by the British Association.

The case before us contains a model of the Wealden area, by Mr. W. Topley and Mr. J. B. Jordan. In this model the geographical structure of the Weald and the position of the boring are clearly shown. There are also a number of solid cores of rock drilled out by the boring tools: some of these were extracted by the old-fashioned tools employed at the commencement of the work, but most of them were obtained by the diamond-mounted drills. Some of these steel crowns, set with rough black diamond or carbonado (p. 123), are here exhibited; whilst the machinery employed at the surface is represented in the accompanying photographs. The borings were commenced in the Purbeck series, and valuable beds of gypsum (p. 43) were discovered at a moderate depth; this mineral is now worked commercially at Netherfield, and several large cores of gypsum will be seen in the lower compartment of the case. A great thickness of Kimeridge clay was penetrated, much of which was found to be highly fossiliferous, and many of these fossils are exhibited as they were found embedded in the cores of shale. Below the Kimeridge clay the borers reached beds of doubtful geological age, probably either Oxford clay or representatives of the Coralline Oolites. Our knowledge of the thickness and succession of some of the Sub-Wealden secondary rocks has thus been considerably extended by this exploration; and although palæozoic rocks have not been reached, it must be admitted that the original object of the experiment has been fully attained.

No. 17.—MODEL OF A PORTION OF THE UNDERCLIFF, ISLE OF WIGHT,  
by Capt. Boscawen Ibbetson, K.R.E.

This model represents a portion of the south side of the Isle of Wight, extending from Bonchurch to Sandown Bay. The chalk, which stretches across the island from east to west, forming the downs or undulating tracts of high ground, is seen to rest immediately upon the upper greensand, which is separated from the lower greensand by a band of gault. The upper greensand slipping over the surface of the gault clay has given rise to the romantic scenery of the Undercliff. For further information, see "The Geology of the Isle of Wight," by H. W. Bristow, F.R.S., published in the "Memoirs of the Geological Survey."

No. 18.—MODEL ILLUSTRATING MANUFACTURE OF BESSEMER STEEL.

The process of making the celebrated Bessemer steel is well illustrated in this model, which was constructed by Mr. T. B. Jordan from drawings furnished by Mr. Bessemer. Cast-iron suitable for conversion into steel by this process is smelted from Cumberland hæmatite (p. 108), or from other ores nearly free from phosphorus. The iron having been melted is run through a gutter

into the "converter," where it is exposed to the oxidising action of a blast of atmospheric air. The converters, marked AA in the model, are constructed of wrought-iron plates riveted together and lined with fire-clay, ganister, or other refractory materials. A sectional model in the lower part of the case shows the construction of these vessels. Two three-ton converters are represented in the model; one in a horizontal, the other in a vertical position. Each vessel is suspended upon two trunnions, and can be rotated by means of a double-acting water-pressure engine, the piston-rod of which carries a rack gearing into the pinion on one of the trunnions. While the metal is running in, the converter is horizontal, but when charged it is slowly swung into an upright position, and air is then blown into the molten metal through twyers in the bottom of the converter. One of the fire-clay twyers is exhibited in the case below. The blast is produced by blowing-engines FF, worked by steam cylinders attached; and the air reaches the vessel by passing up one of the trunnions which is hollow. On admission of air the carbon and silicon are rapidly oxidised, and a flame issues from the mouth of the converter followed by brilliant showers of sparks. When the last trace of carbon has been removed, as indicated by changes in the character of the flame, the converter is tilted back into a horizontal position, and a due quantity of molten spiegeleisen (p. 59) is run in. The precise proportion of carbon required to form steel is thus supplied to the iron, which has been completely decarburised by the blast, and the melted steel is then poured from the converter into a large ladle. This ladle is carried at one extremity of a moveable platform C, which is caused to traverse the casting-pit by means of a handle connected with spur-gearing. The ladle is a large wrought-iron vessel lined with fire-clay, and having a hole at the bottom for running the metal off into the moulds. A series of these cast-iron moulds is placed round the floor of the casting-pit, and several steel ingots are also represented. The ladle is carried round until the hole is directly over one of the moulds, when the plug which closes the aperture is lifted by a lever, and the metal escapes. The ingots are lifted from the casting-pit by means of the hydraulic cranes DD. At E is a set of hydraulic pumps for supplying the water-pressure which moves the converters and the cranes; whilst the working of the whole apparatus is regulated by the gearing represented at B.

Some fine examples of steel manufactured by this process, and presented by Mr. Bessemer, are distributed over the vacant space on the floor of the model, and others are exhibited in the lower compartment of this case and of case 7.

No. 19.—LARGE VASE OF FLUOR SPAR.—*Presented by S. Addington, Esq., F.S.A.*

This handsome vase is formed of a beautiful variety of Fluor spar, which occurs only at a single hill called Tre-cliff, near Castleton in Derbyshire. It is a mineral of finely-variegated purple tints, known locally as "Blue John," a name adopted by the Derbyshire miners to distinguish it from "Black Jack," or zinc blende (p. 83). The Derbyshire spar was not known until the year 1770, but it has since been so largely employed for ornamental purposes that the true "Blue John" is no longer to be obtained. The spar rarely occurred in masses of large size, and hence the difficulty of procuring material for manufacturing so large a vase as that exhibited. This vase, which is constructed of several pieces, is 2 ft. 8 ins. high,

and its greatest circumference is about 3 ft. 7 inches. It was made by Mr. Vallance, of Matlock, and it is believed that it is exceeded in size and beauty by only one other vase of fluor-spar, which is in the possession of the Duke of Devonshire at Chatsworth. For a mineralogical description of fluor-spar, see p. 131.

No. 20.—SLAB FROM THE BONE-CAVERN OF LES EYZIES.—*Presented by the late M. Lartet and H. Christy, Esq.*

This slab of osseous breccia was obtained, by the donors, from the floor of the bone cavern of Les Eyzies, in the valley of the Beune, a tributary to the Vézère, in Dordogne. The bones are chiefly those of the reindeer, and are in most cases fractured, having probably been broken for the extraction of the marrow. These bones are associated with great numbers of worked flints, rolled pebbles, and fragments of foreign rocks, the whole being cemented together by stalagmitic carbonate of lime. The most interesting relics of human workmanship in these deposits are rudely-engraved pieces of bone and plates of schistose rock, which are undoubtedly the earliest known specimens of the engraver's art. In the block before us there has been found a small bone needle, and a human tooth was detected in a similar slab sent to Vienna.

The bone deposits of Dordogne are referable to a remote era, when the use of metal was apparently unknown,—an era posterior to that of the mammoth, and characterised by the presence of the reindeer in certain southern districts where it has not been found during the historic period. For information on the French bone-caves the visitor should refer to Messrs. Lartet and Christy's *Reliquiæ Aquitanicæ*, edited by Professor T. Rupert Jones, 1875.

No. 21.—MODEL OF STEEL WORKS AT SHEFFIELD.—*Presented by Messrs. Naylor, Vickers, and Co., Sheffield.*

Whilst the modern process of making Bessemer steel is illustrated by the large model, No. 18, the older process of producing steel by what is called "cementation" is well shown in the model before us. The steel is in this case produced from the malleable iron by causing the metal to take up additional carbon, but not, however, in sufficient quantity to form cast-iron; the result of this process of conversion is known as *cement steel*, or *blister steel*. Bars of malleable iron are imbedded in coarsely-powdered charcoal in large boxes, and exposed for a long time to a full red heat. To prevent the charcoal from burning away, and to confine its action as much as possible to the iron, the whole is covered with sand or earth which will not easily vitrify. In Sheffield a stiff ferruginous mud, called *wheels-wharf*,—the stuff which is produced by the wearing of the grindstones,—is generally used. Every unnecessary aperture is carefully closed. The chest containing the iron and charcoal, which holds from 13 to 17 tons of metal, is then exposed in the converting furnace to the action of fire, which is maintained at a high intensity for several days, when the bars of iron will be found to have taken up carbon and to be converted into steel. The theory of this process of conversion whereby the carbon of the charcoal combines with the iron is far from clear.

This model represents the arrangements also for melting and casting steel, and for rolling it into bars, &c. Specimens of steel are exhibited in case 51 (p. 120), and a collection of steel will be found on the walls of the MODEL ROOM.

## No. 22.—WATER BAROMETER.

This instrument will be found at the northern end of the room, near Wall-case 29. From the ordinary mercurial barometer it differs only in the substitution of a column of water for one of quicksilver; but since water is, bulk for bulk, about  $13\frac{1}{2}$  times lighter than quicksilver, it is obvious that the column of water necessary to counterbalance the atmospheric pressure must be  $13\frac{1}{2}$  times longer than that used in our ordinary instruments; thus, while the mean height of the mercurial barometer is about 30 inches, that of the water barometer will be upwards of 33 feet. Apart from other objections, the manifest inconvenience of so unwieldy an instrument forbids its general adoption, but the extreme sensibility of its indications gives it considerable scientific interest; the column of water being sensibly affected by variations in aerial pressure too slight to produce any perceptible effect on the mercurial barometer. The indications are, however, seriously affected by the pressure of the water vapour which escapes into the space above the column.

Some years back, an instrument similar in principle to the one before us, but different in construction, was erected by the late Professor Daniell, in the Royal Society's Hall. In the instrument here exhibited, which was constructed by Mr. J. B. Jordan, the glass tube forming the upper part of the barometer is alone exposed, the metal tubing constituting the lower portion being carried downwards to the basement of the building, where it terminates in a cistern of water, the surface of which is covered with a stratum of mineral oil to prevent evaporation of the liquid and absorption of air. Mr. Jordan has since successfully constructed glycerine barometers, which have the advantage of affording more accurate readings, since the glycerine gives off vapour of low tension which does not depress the fluid column to the same extent as the aqueous vapour does in the water barometer.

## No. 23.—MODEL OF LEAD-FUME CONDENSER AT WANLOCK HEAD WORKS.

The fumes are conveyed from the flues into a double-chambered condenser, where the lead is separated by passing through showers of water; the purified smoke escaping through a tall chimney, while the water is collected in a reservoir where the lead is deposited. It is employed at the Duke of Buccleugh's lead works at Wanlockhead, in Dumfriesshire.

## No. 24.—MODEL OF A CORNISH MINING DISTRICT.

This model, constructed by Mr. T. B. Jordan, under the direction of the late Sir H. T. De la Beche, shows the character of the ground in a typical mining district in Cornwall, and exhibits the principal rocks, granite, and killas, intersected by mineral lodes, cross courses, &c. See description at p. 97.

## No. 25.—MODEL OF COMSTOCK LODE AND PROJECTED SUTRO TUNNEL, NEVADA.

*Presented by A. Sutro, Esq.*

The celebrated Comstock lode, shown in this model, is probably the most productive silver-bearing vein in the world. It is situated on the eastern slope of the Washoe mountains, a range of hills running parallel to the Sierra Nevada. The lode was discovered in 1859, and has been traced for several miles in a direction nearly parallel to the magnetic meridian. Numerous workings

have been established on the lode, and several cities planted on its outcrop. Virginia city is at an altitude of 6,205 feet. The Washoe range culminates in Mount Davidson at an elevation of 7,827 feet. This mountain is formed of syenite, which, with various metamorphic rocks, constitutes the nucleus of the range. A younger series of volcanic rocks, probably of Tertiary or Post-tertiary age, is represented by the sanidine-trachyte and by Baron Richtofen's propylite; the latter consists of a fine-grained paste with embedded crystals of oligoclase and hornblende. The geology of the country and its physical features are well shown in this model.

It was proposed a few years ago by Mr. Adolph Sutro to drive a deep adit or horizontal tunnel, four miles long, through the heart of the mountains until it cut the workings on the Comstock vein, at a depth of about 2,000 feet. It would thus afford an outlet to the waters which at present give considerable trouble to the miner; but in addition to securing drainage it might be used for underground transit of the ore, and thus avoid the difficulty of transport across a hilly country. It was proposed to establish reduction works at the mouth of the tunnel. The model shows the direction of the projected adit, and indicates by a thick black line the portion of the tunnel which had been driven at the time the model was constructed. For statistics of production of the Comstock Lode, see p. 94.

**No. 26.—MODEL OF THE WORKINGS OF THE CLUNES AND PORT PHILIP MINING COMPANIES, VICTORIA, AUSTRALIA.**

The raising and crushing of the quartz, and the extraction of the gold, are represented in this model, which, however, requires no detailed explanation, since each portion is furnished with a number referring to an explanatory key which accompanies the model.

In the case beneath are placed some samples of *gold-bearing quartz* and "*wash-dirt*," from Australia, together with a model illustrating the *Australian mode of timbering shafts*. With these will be found a working model, by Mr. J. B. Jordan, of a *horizontal high-pressure engine*, furnished with a pair of fly wheels.

**No. 27.—MODEL OF PART OF THE LEAD MINING DISTRICT OF ALSTON MOOR, CUMBERLAND.**

This model, which was constructed by Mr. T. Sopwith, represents part of the mining district adjoining the river Nent. It exhibits the thickness and inclination of the strata of limestones, hazels (or sandstones), and argillaceous beds. In the front of the model is shown the celebrated "*Nent-force level*." This work was projected in 1775, by Smeaton, and being judiciously carried out, it has been of the greatest advantage to the district. "*Nentsberry engine shaft*, represented on the model, is sunk down to Nent-force Level,  $3\frac{1}{2}$  miles from the entrance. The whole of this distance, which was then navigable in boats, was surveyed by the author in 1826; it has since been continued, as shown in the model, on the top of the stratum of limestone called the *Scar limestone*. The usual mode of entrance to the lead mines of Alston is by means of adits or water levels, made sufficiently large for a horse to travel in. The entrance or *level mouth* of Nentsberry Green mine is shown on the model, and the several *rises* by which access is gained to the veins of ore in the *great limestone*."—(Sopwith.)

The mineral veins are seen on the side of this model descending in nearly a vertical direction through the various strata. It will be observed that those layers are not opposite each other on either side of the vein. The cause producing the fissure in which the mineral matter has been deposited has occasioned the subsidence of all the strata on one side of the lode. Hence the mineral vein may have limestone on one side and sandstone on the other, or sandstone and clay may be opposite. It has been observed that the metalliferous character of the vein is in a great measure dependent upon the arrangement of the strata on either side of the lode. In this district the lead is usually found in the limestone, and when limestone forms both cheeks or sides of the vein it is generally there the most productive.

*Old Carrs crop-vein* in the model has, to use the miners' phrase, *thrown down* the strata 25 fathoms, whereas at *Wellgill crop-vein* the amount of vertical disturbance is only 3 fathoms. The great limestone is  $9\frac{1}{2}$  fathoms thick, consequently it follows that the last-named vein has limestone sides for  $6\frac{1}{2}$  fathoms (39 feet).

#### No. 28.—MODEL OF LANDSLIP AT AXMOUTH.

At Christmas 1839, this great landslip took place. The model is constructed on the scale of 120 feet to an inch, and it represents a mile and a quarter of the country over which the subsidence took place. The length of the great chasm caused by this subsidence was 1,000 yards, the breadth 300 yards, and the depth varied from 130 feet to 210 feet. Twenty-two acres were sunk in the chasm. The Rev. W. D. Conybeare thus describes the phenomenon :—

"On the morning of Tuesday the 24th, about three o'clock a.m., the family of Mr. Chapple, who occupied the farm of Dowlands, about half a mile from the commencement of the disturbances which ensued, was alarmed by a violent crashing noise; but nothing farther was observed through that day. On the following night, however, about the same hour, some labourers of Mr. Chapple, the tenants of cottages built among the ruins of the adjoining undercliff, hurried to the farm with the information that fissures were opening in the ground around, and the walls of their tenements rending and sinking. Through the course of the day following (Christmas) a great subsidence took place through the fields ranging above Bendon Undercliff, forming a deep chasm, or rather ravine, extending nearly three-quarters of a mile in length, with a depth of from 100 to 150 feet, and a breadth exceeding 80 yards. Between this and the former face of the undercliff extends a long strip exhibiting fragments of turnip fields, and separated from the tract to which they once belonged by the deep intervening gulf, of which the bottom is constituted by fragments of the original surface, thrown together in the wildest confusion of inclined terraces and columnar masses, intersected by deep fissures, so as to render the ground nearly impassable. The insulated strip of fields also which has been mentioned is greatly rent and shattered. The whole of the tract which has been subjected to these violent disturbances must be estimated on the most moderate computation as exceeding three quarters of a mile in length by 400 feet."

#### No. 29.—MODEL OF PEAT MOSS IN AUCHENGRAY ESTATE, LANARKSHIRE, by Thomas Gibb.

This model of a peat moss, which slipped on the 12th and 15th August 1861, is accompanied by a descriptive label, affording sufficient explanation, which it is unnecessary to repeat here.

No. 30.—MODEL OF HOLMBUSH MINE, *by Mr. T. B. Jordan.*

In this model of Holmbush mine, near Callington, in East Cornwall, the excavations are represented by solid modelling, whilst the surrounding country below the adit-level is supposed to be removed, and hence appears as space. By this novel principle of modelling, for which a prize medal was awarded at the International Exhibition, 1862, the direction of the lodes and the details of the underground workings are distinctly seen, whilst the difference in the mineral contents of the veins is represented by a system of colouring, explained by a label attached to the model.

In 1863 Holmbush mine produced 1,048 tons of copper ore and 416 tons of lead ore. The workings are, however, now abandoned. A fine sample of the copper pyrites is placed beneath the model.

There are also exhibited in the lower part of this case a remarkably large crystal of *Canadian Mica*, belonging to the variety called phlogopite; and a fine example of *magnetic iron ore* from Sweden.

A small model showing the *Geology of Jerusalem* is placed here temporarily.

No. 31.—MODEL OF SURFACE-WORKINGS OF A NEWCASTLE COAL-PIT.—  
*Presented by Mr. John Wales.*

This model, the several parts of which are lettered, represents the arrangements used at a North of England colliery, for raising, screening, and loading the coals. From the face of the workings in the pit, the coal is brought in tubs or waggons (G) which are placed on cages (D), and raised to the surface by the winding engine (A), which, with its two boilers (B), occupies a prominent position in the upper part of the model. Arrived at the top of the pit (C), the tubs (G) are placed in the *teaming cradles* (F), and the coals discharged upon the screens (I, I), the large coal passing directly into the chaldron waggons (H), while the small coal passes into the box (K), whence it is transferred to the small-coal screen (L) by which it is sorted into the three sizes, *nut, seconds, and duff*, discharged through the shoots marked respectively M, N, O.

In the same case is a *model of cages used at Cowden Colliery, Dalkeith*, presented by His Grace the Duke of Buccleuch and Queensberry, K.G. There is also exhibited in this case a model of a horizontal winding engine, with spiral drum, for colliery work.

MODELS OF THE MACHINERY FOR LOADING COAL.—In lower compartment of Case No. 31.—*Presented by Messrs. Vivian and Sons, Tai-bach, Glamorganshire.*

It will be observed that in one instance the waggon on the rails runs on to a stage, which is lowered into the vessel's hold, when it is opened at the bottom, and the large coal quietly deposited in its place, the stage being returned to its original position by counter-balance weights. The second model is similar in general principle, but here a box slung at the end of a crane is employed instead of the sliding stage.

## No. 32.—SPECULAR IRON ORE FROM THE ISLAND OF ASCENSION.

A notice of the volcanic island of Ascension will be found in the "Catalogue of Rock Specimens," 3rd ed., p. 220. The formation of specular iron ore in volcanos probably results from the action of watery vapour on perchloride of iron; hydrochloric acid being set free, whilst peroxide of iron is deposited in a crystalline form.

Reference to Wall-case 18 will show that specular iron ore is by no means an unfrequent volcanic product.

#### No. 33.—CASE OF MINERAL SPECIMENS.

Several remarkably fine mineral specimens, too large to be exhibited elsewhere, are here grouped together. Descriptions of these will be found under their respective headings.

#### No. 34.—GEOLOGICAL MODEL OF MONT BLANC.

Mont Blanc forms the culminating point of the chain of the Pennine Alps and is well known to be the highest mountain in Europe, its altitude being 15,732 feet above the sea-level. The model was constructed by Mr. J. B. Jordan. It is to be noticed that the vertical and horizontal scales are the same, so that the heights are not exaggerated, as is generally the case in geological models and sections.

The snowline, or limit of perpetual snow, comes down to about 7,000 feet below the summit of Mont Blanc, and the model shows with great clearness the system of glaciers with their different forms of moraine,—lateral, medial, and terminal. The deep red colour on the highest part of Mont Blanc and the surrounding heights represents the peculiar rock called *protogine*, a talcose variety of granite, whilst the paler red denotes mica schist, and the bright yellow, on the opposite sides of the valleys of the Arve and the Dora, marks the distribution of rocks of liassic age.

#### No. 35.—MODEL OF THE PASS OF MONT CENIS.

This model shows by the contour-lines the various elevations, and exhibits the physical features of the country. The district represented does not extend sufficiently westward to include the country penetrated by the celebrated railway tunnel.

In the upper part of Wall-cases 8 and 9 are several other illustrations of this system of modelling.

The lower compartment of the case contains a fine sample of *gold and silver ore from Chile*. This specimen is from the Madre de Dios mine, near Coquimbo. It contains the precious metals in the proportion of 12 ozs. of gold and 220 ozs. of silver to the ton.

A few other mineral specimens also find place here, including a rich mass of silver and copper ore from Newfoundland, presented by the Hon. C. F. Bennett.

#### No. 36.—AUSTRALIAN GOLD, &c.

It appears that in 1839 Count Strzelecki discovered traces of gold in Australia, but on relating the circumstance to the Governor of New South Wales secrecy was enjoined, and the Count never reverted to the subject. In 1841 the Rev. W. B. Clarke wrote to a friend in the colony, mentioning that he had found gold ore, but neither of those facts was published in the colony, and they were wholly unknown in Europe. The study of the auriferous tracts of the Uralian mountains enabled the late Sir R. I. Murchison, in 1844, to predict the discovery of gold in Australia. "Having," writes Sir R. Murchison, "in the year 1844 recently returned from the auriferous Ural mountains, I had the advantage of examining the numerous specimens collected by my friend Count Strzelecki along

the eastern chain of Australia. Seeing the great similarity of the rocks of those two distant countries, I could have little difficulty in drawing a parallel between them; in doing which I was naturally struck by the circumstance that no gold 'had yet been found' in the Australian ridge, which I termed, in anticipation, the 'Cordillera.' Impressed with the conviction that gold would, sooner or later, be found in the great British colony, I learned in 1846, with satisfaction, that a specimen of the ore had been discovered. I thereupon encouraged the unemployed miners of Cornwall to emigrate and dig for gold, as they dug for tin in the gravel of their own district. These notes were, as far as I know, the first published relating to Australian gold."

Of the *Auriferous Drift* of Victoria we have the following account, by Mr. Alfred R. C. Selwyn, late Geological Surveyor of that district, and formerly of the Survey of the British Isles:—

"This formation, of very late tertiary date, varies in thickness from a few inches to 100 feet and upwards. It consists of stratified and unstratified masses of ferruginous clay, sands, and gravel, interspersed with angular and partially rounded fragments of clay, slate, sandstone, quartz, &c.

"It occurs almost universally, distributed in the gullies, on the flats, and over the hills, occupied by the palaeozoic strata, and is, in fact, formed from the decomposition, breaking up, and spreading out of the immediately subjacent rocks; the fragments found in it being, with a few local exceptions, seldom much water-worn, and bearing no evidence of having been transported from a distance. The lowest stratum or bottom almost always varies in colour and character with the nature of the subjacent rock, whether a ferruginous clayey sandstone, forming a red or mottled ferruginous sandy clay or gravel, or a soft felspathic slate, producing a white pipe-clay, &c.

"With respect to the origin and present position of the gold, there can, I think, be little doubt, 1st, that the whole of it has been formed in or near the quartz veins which are now seen traversing the palaeozoic strata; 2nd, that its present position in the drift is entirely due to the decomposition, breaking up, and spreading abroad of these quartz veins along with the ordinary sandstones, slates, &c. of the district."

*GEMS from Australia.*—Specimens of sapphire, topaz, zircon, and other gems occurring in the alluvial gold-deposits are here exhibited. With these are two Australian diamonds, one of them being the earliest brought to this country. Several quartz crystals have been brought to England under the impression of their being diamonds. A quartz crystal is usually a six-sided prism, with a six-sided pyramid at its end, a form which the diamond never assumes. Diamonds are either eight-sided crystals (octahedrons), cubes or dodecahedrons; or more complicated forms closely related to these solids.

#### NO. 37.—MODEL OF THE ALPS AND THE PLAINS OF LOMBARDY.

This model, presented by the late Dr. Fitton, is based upon Jomini's map illustrating Napoleon's wars. The mountains represented include the Alps, from the sea nearly to the end of the Rhætian chain, the whole range of the Jura, and a part of the Apennines. It exhibits the physical features of the country, but not its geology.

No. 38.—ELECTRO-METALLURGY. Head of OCEAN (No. 39). Head of MELPOMENE. (No. 9)—*presented by Elkington, Mason, and Co.*—near the gallery stairs on either side. Specimens in Wall-cases 15, 16, 17. *Frame on wall near Case 14.*

The discovery of the process of the electrotype, or electrometallurgy, was first announced to the public on the 4th of May 1839, by Professor Jacobi, of St. Petersburg.

On the 8th of May Mr. Spencer announced to the Liverpool Polytechnic Institution his discovery; and on the 22nd of the same month Mr. C. J. Jordan published in the *Mechanics' Magazine* a description of his method. Here we have an instance, not an uncommon one, of three men, Jacobi, Spencer, and Jordan, working at the same time upon a most important discovery, without either of them being in the least aware of the researches of the other.

Electro-metallurgy depends upon the law established by Dr. Faraday, that the electricity developed by the change of state, *oxidation*, of an equivalent of one metal, zinc, would effect the decomposition of an equivalent proportion of another metal, copper, from its solution.

The form of a voltaic battery for the electrotype process is exhibited. A plate of zinc and a plate of copper being placed in some diluted sulphuric acid, an action is immediately established on the zinc; it is first oxidized, and the oxide of zinc formed is converted into sulphate of zinc, by being dissolved in the sulphuric acid. During the oxidation of the zinc, electricity is developed, which passes to the surface of the copper plate. If from each of those plates a copper wire is carried into a solution of sulphate of copper, a piece of plain copper being attached to one wire and connected with the copper plate, and an engraved plate or a medal to the wire connected with the zinc plate, the result will be that copper will be deposited in a metallic form upon the engraved plate or metal, and copper will be dissolved off from the plate on the other wire. In the frame on the wall, near Case 14, is a plate of copper as precipitated, another plate as thrown down upon an engraved surface, which gives all the lines in relief; upon this another deposition being made, the result is, as shown, an exact fac-simile of the original plate. As an example of an application of this, the maps used by the Geological Survey of Great Britain are copied from the plates of the Ordnance Survey by the electrotype process; upon the plates thus obtained are engraved the geological lines, signs, and remarks, so that every information required by the public appears on the geological map, without at all disturbing the character of the ordnance map. Many surfaces, such as clay, plaster of Paris, wax, &c., are not conductors of electricity, and consequently upon these metal cannot be precipitated. The late Mr. Robert Murray discovered that black lead, *plumbago*, rubbed over such articles gave them at once a conducting surface, and rendered them fit for receiving, by the voltaic battery, a metallic precipitate. Thus are formed several of the objects exhibited.

If silver or gold is to be deposited, the oxides of these metals must be dissolved in cyanide of potassium or some such salt. The article being immersed in this, when connected with the battery, silver or gold is deposited. This is electro-plating. To prevent the silver from presenting a granular or dead appearance, a few drops of the bisulphide of carbon are added to the solution.

*The Botanical Specimens, &c.*, of which there are exhibited electrotype coatings, may be prepared by dipping, first the grass or leaves into a solution of phosphorus in bisulphide of carbon, then plunging the article into a solution of nitrate of silver. The thin film of

phosphorus left upon the surface occasions a precipitation of a finely-divided coat of silver, upon which, when connected with the battery and placed in the proper solutions, any quantity of either copper, silver, or gold can be deposited. It is impossible to do more than thus indicate a few of the processes by which electro-metallurgy has been carried forward.

Some of the most interesting results have been the coating of iron with copper, and the electro-chemical deposition of the compound metal, brass, of which some examples are shown. One of the most recent applications of electro-metallurgy on a large scale has been the electro-deposition of nickel on various metals. It is believed that the nickel is best thrown down from a solution of a double salt, such as a double sulphate of nickel and ammonia. The process is now largely worked in London and Birmingham, and several specimens, presented by the Nickel Plating Co., Limited, are exhibited in the opposite side of the glass case. These samples show the deposition of nickel on slabs of copper, tin, cast-iron, steel, brass, and German silver.

PHOSPHOR-BRONZE.—The upper shelves of this case, on the opposite side to that containing the electro-metallurgical series, are devoted to the exhibition of specimens of this alloy, presented by the Phosphor-bronze Co., Limited. A good deal of attention has recently been directed to the value of adding phosphorus to bronze, whereby the quality of the metal is said to be greatly improved. Experiments have shown that this alloy possesses high tensile strength, and other valuable mechanical properties; and its manufacture has consequently been established in this country. The manifold applications of phosphor-bronze are well illustrated by the specimens exhibited in the case before us.

No. 40.—*Eozoön* IN LAURENTIAN SERPENTINOUS LIMESTONE.—Presented by the late Sir W. E. Logan, Director of the Geological Survey of Canada.

The Laurentian rocks of Canada, which are developed on a vast scale in the country north of the St. Lawrence, consist chiefly of enormous deposits of gneiss, containing in certain parts intercalated beds of crystalline limestone. The system is clearly separable into an upper and a lower series, and from the uppermost limestone-band in the lower group the block before us was obtained. Considerable interest naturally attaches to the late Sir William Logan's discovery of organic remains in these metamorphic rocks, which are the oldest stratified deposits at present known. The fossil, which has received the name of *Eozoön Canadense*, is referred by Dr. Carpenter and other microscopists, to the group of *foraminifera*. These are animals of extremely simple organization, each foraminifer consisting essentially of a gelatinous mass of protoplasm or "sarcodæ," usually enclosed in a calcareous covering or test. In the *eozoön* this calcareous shell is but little altered, whilst the easily decomposable sarcodæ is replaced by mineral silicates, such as the green serpentine in the block before us. When a thin section of this fossil is treated with hydrochloric acid the calcareous shell is dissolved while the mineral silicate remains in the form of casts of the original body-chambers of the organism. Such a decalcified section is exhibited in the opposite case, No. 43.

No. 41.—MODEL OF THE CHAIN OF PUIS, AUVERGNE.—Presented by the late G. Poulett Scrope, M.P., F.R.S., &c.

Little more than a century ago two French travellers returning from Italy observed that the rocks in certain parts of their route

through Central France bore a striking resemblance to the volcanic products of Vesuvius. Although at first received with considerable opposition, the truth at length became established, that at a comparatively recent geological period the interior of France had been the theatre of energetic and frequently-repeated volcanic action. One of the most interesting groups of these extinct volcanos is represented in the model before us.

The volcanic hills of the department of the Puy-de-Dôme form an irregular chain, running nearly north and south, and rising from the great plateau of granite which forms so prominent a feature in the geology of Auvergne. The surface of this granite presents several depressions, formerly occupied by lakes, the existence of which is now marked by certain fresh-water deposits, of which the largest forms the fertile plain of the Limagne, represented on the eastern side of the model. Passing westward from the alluvial valley of the Allier, we cross the calcareous marls and other lacustrine deposits on the margin of the Limagne, and reach the eastern escarpment of the granitic table-land which, extending in width for about 12 miles, slopes on the western side to the valley of the Sioule. The chain of "puys," which rises from this platform, includes about 70 volcanic hills, of which the largest is the Puy-de-Dôme, a mountain rising 4,844 feet above the sea level. Most of these hills are composed essentially of the scoræ, lava, and other volcanic products, which, accumulating around the orifices of eruption, have formed conical hills, often presenting at the summits well-defined craters, from which, in many cases, distinct streams of lava may be traced. The Puy-de-Dôme and a few other hills consist, however, of a peculiar trachytic rock called *domite*. A descriptive label, by Mr. Scrope, accompanies the model, and a notice will also be found in the Catalogue of Models. For further information see "The Geology and Extinct Volcanos of Central France," by G. Poulett Scrope, M.P., F.R.S., &c.

In the drawers beneath the model is an interesting group of rock specimens illustrating the geology of the district, presented mostly by Dr. C. Le Neve Foster, B.A., F.G.S.

#### NO. 42.—CRYSTALLINE FURNACE PRODUCTS.

A small table-case at the head of the steps leading from the Hall, opposite to the large model of Auvergne, contains a series of crystalline furnace products, forming a companion group to the specimens of slags on the opposite side of the steps (see p. 55).

Among the more notable specimens attention may be directed to some fine examples of the bright copper-red cubic crystals of a peculiar compound of *titanium* (p. 84), not unfrequently found in the "bear" of blast furnaces. These crystals to which Dr. Wollaston first drew attention, were formerly thought to be pure titanium, but it has been shown by Dr. Wöhler's researches that they consist of nitride of titanium with cyanide of titanium. The specimens of crystallized *oxide of zinc* from the iron furnaces of Westbury are also interesting. The fine specimen of a furnace product having the composition of magnetic oxide of iron, and exhibiting an aggregate of octahedral crystals, will not fail to catch the visitor's eye; nor will the other artificial minerals escape attention, such as the crystals of galena from the Freiberg lead furnaces, or of orthoclase from the Hartz copper-works. There is also exhibited here a beautifully-crystalline compound of peroxide of iron and lime, thus related in composition to the natural group of spinels, which has been produced by Dr. Percy, who described it in the *Philosophical Magazine* for June 1873.

## No. 43.—ART APPLICATIONS OF THE METALS.

The object of the articles grouped in this case is to show the characters of the metals in a pure and a mixed state, and to illustrate their application to works of art and to art manufacture.

*Statuettes in tin and copper* show the characters of the metals in their ordinary states. One in *brass* exhibits the result of combining copper and zinc, while those of Raphael and Michael Angelo are bronzes, in the proportion of 90 parts of copper and 10 of tin. The statuette of Humboldt is of zinc, but it has been subsequently coated by the electro-chemical process.

The *silver and bronze vases* are copied from antique specimens found in Pompeii, and now in the Museo Borbonico at Naples. *Corinthian bronze*, in which one of them is cast, consists of two-thirds copper and one-third silver. This composition is said to receive its name from its having been discovered by the accidental melting together of statues of copper and silver which were destroyed by fire at Corinth. At least 700 years before Christ the art of casting bronze statues was carried to a high degree of refinement. Pliny informs us that it was during the reign of Alexander that the production of bronze statues received its greatest extension under the guidance of the artist Lysippus, who improved the modes of moulding and casting. Pliny calls these statues the *mob of Alexander*. Athens is said to have contained above 3,000 bronze statues. Rhodes, independently of its lighthouse and its bronze tower, was decorated with as large a number, and in Olympia and at Delphi they appear to have been no less numerous. We are thus enabled to form some idea of the extent to which metallurgy was carried by the ancients. *Electrum* was one of the celebrated mixed metals of the ancients, of which we have here an example.

Our *standard silver* (see Silver Vase) has a composition of 222 silver and 18 copper; by the admixture of the latter metal the required hardness is obtained without interfering with the colour of the silver.

An example of a mixture of platinum and silver will also be found in this case.

The *German silver* will be noticed in connexion with the nickel series (p. 114); and the *aluminium bronze* will be mentioned in the description of an adjacent case (p. 75).

*The Bronze Lizards and other Castings*.—Castings of this kind are obtained by pouring upon the living animals a cream of plaster of Paris; this soon sets and the animal dies. By exposing the plaster after it is dry to a high temperature all the organic matter is destroyed, and a perfect mould is left, into which the metal is poured. Chantry was one of the first to employ a process of this kind, for the purpose of obtaining *fac-similes* in metal of leaves and flowers.

## No. 44.—CHINESE BRONZES, &amp;c.

Productions of this kind have long been made by the Chinese, and they exhibit very great ingenuity in their modes of moulding, and adjusting the mould so as to secure, as nearly as possible, a perfect coating by one operation, without the subsequent use of the tool.

In many instances the model is most carefully made in wax, and all the ornamentation, inscriptions, and the like elaborately finished; this is then covered with the clay which is to form the mould, and when dry the wax is melted out; the metal which subsequently in a

fluid state supplies its place fills every part, and thus is obtained a casting of great sharpness and correctness.

The *tam-tams* and *cymbals of bronze* of the Chinese are forged with the hammer, as indeed are many of their bronze articles. The composition of these appears to be 78 of copper and 22 of tin. This alloy, when newly cast, is very brittle, but being confined between discs of iron heated to cherry redness and plunged into cold water, it becomes malleable. The Chinese bell—*tshoung*—which we render *gong*, is usually composed of 80 copper, 20 tin; these are worked with the hammer as described. The Chinese frequently employ copper alone, and give it artificially the character of bronze by spreading upon the surface a paste of verdigris, cinnabar, sal ammoniac, and alum, and then exposing the vessel for some time to the action of a moderate fire.

*Chinese Mirrors.*—Many of these mirrors possess the very remarkable property of reflecting from their polished surface the figure which is wrought upon the back.

Chinese copper, some of that metal and several alloys from Japan, a Chinese lock and key, &c., will also be found in this case. There are likewise some examples of Indian niello work on tinned copper.

#### No. 45.—MINERAL SPECIMENS.

Two fine mineral specimens are placed under glass shades on a small table, between the Pedestal-cases Nos. 44 and 46. One of the specimens is an example of fibrous *malachite*, or green carbonate of copper from the Peaks Down Copper Mines, New South Wales; the other is an attractive specimen showing crystals of *Amazon stone* or green felspar, with quartz and spathic iron ore, seated on the walls of a cavity in a granite rock from Rockport, Massachusetts, U.S.

#### No. 46.—METEORITES, ALUMINIUM, PRECIOUS METALS, &c.

A miscellaneous assemblage of specimens is temporarily exhibited for convenience in this case. Most of the objects fall into the metallurgical series, but a few other specimens, such as the meteorites, are also included in this collection.

*METEORITES.*—The small collection of meteorites here exhibited, includes some fine specimens of meteoric iron and several fragments of meteoric stones. The former consists of iron alloyed with a small quantity of nickel and cobalt, and frequently contains graphite and other minerals; whilst the latter are aggregates of various simple minerals, such as felspar, augite, and olivine. Some of the specimens of meteoric iron show the figures of Widmannstätten, *i.e.*, the crystalline structure developed by the action of nitric acid on a polished surface. Numerous meteorites have fallen in various places, but the origin of these masses is still wrapt in obscurity; the most rational theory is that of Chladni, which may be expressed in the following general terms:—Through the interplanetary spaces, and it may be through the interstellar spaces also, vast numbers of small masses of solid matter may be moving in irregular orbits; and these, as they approach any planet of powerful gravitation, such as the earth, will be disturbed, and may fall towards its surface.

The theory of Laplace was, that these *aérolites* were projected from volcanos in the moon. It has, however, been proved that there are no active volcanos in our satellite; consequently this theory cannot be received.

*ALUMINIUM.*—In a state of powder aluminium has been known since the days of Davy; Oersted wrote on it and some of its alloys; and Wöhler and other chemists prepared it. M. St. Claire Deville

was, however, the first to obtain the metal in a perfectly coherent form. Until recently the mineral called *eryolite*, a double fluoride of aluminium and sodium, of which a specimen is shown, was the principal source of aluminium; but at present the metal is exclusively obtained from *bauxite*, a French mineral, containing more than one-half its weight of alumina, together with peroxide of iron, silica, titanium, and water. By heating a mixture of bauxite and soda-ash an aluminate of soda is obtained, and from a solution of this salt, alumina in the state of hydrate may be precipitated by an acid. A mixture of this precipitated alumina with common salt and charcoal is treated with chlorine, and from the double chloride of aluminium and sodium thus formed, metallic aluminium is obtained by the reducing action of sodium. Each stage of the process is here illustrated. Aluminium has a specific gravity of 2.56; that of silver being 10.5. It does not tarnish under circumstances in which silver, tin, and zinc blaken; and alloyed with copper it forms the well-known *aluminium bronze*, of which several specimens are here shown.

**PRECIOUS METALS.**—The most interesting among these are the specimens of platinum and its associated metals.

Platinum was unknown in Europe till about the middle of the last century, when it began to be imported in small quantities from South America, but from its infusibility it was useless.

Dr. Wollaston discovered a method of fusing platinum, and thus of rendering it available in the arts. Platinum first engaged the attention of the Russians in 1824, when rather more than one pood was collected. In 1836 more than 138 poods were obtained, and within a few years the Russians issued platinum coins of the value of 3, 6, and 20 silver roubles. (See p. 96.)

*Silver coined at Aberystwith.*—The Cardiganshire lead mines are especially remarkable for the attention which they excited during the latter half of the 16th and the beginning of the 17th century. Sir Hugh Middleton realized a large fortune from those mines, and expended it in bringing the New River from Ware to London. After Sir Hugh Middleton's death, Mr. Bushell, the secretary of Sir Francis Bacon, bought the mines of Lady Middleton. These mines were extremely profitable to him, and availing himself of an indenture of Charles I., dated 30th July 1837, he established a mint at Aberystwith. Mr. Waller, in his account of the mines of Cardiganshire, says, "He kept a mint at work at the silver mills of Cardiganshire from the bullion he had at this mine, and is said to have clothed King Charles the First's whole army from part of his profit in this work." It is certain that during the civil wars Mr. Bushell sacrificed his fortune in the King's defence, and that he placed himself at the head of a regiment of miners which he had raised in support of the royal cause. Aberystwith Castle was besieged and taken by the parliamentary forces, and the mint and mines were abandoned. The coins exhibited are some of those coined by this Mr. Bushell.

**ANTIMONY.**—This metal is always extracted from the ter-sulphide (pp. 85, 92), which is separated from its associated earthy impurities by simple fusion, and in this state is known as *crude antimony*. By careful roasting, the sulphide is converted into an oxide, which is then reduced to the metallic state by fusion with carbonaceous matters. Antimony is largely used in the preparation of type metal, which consists of six parts of lead and two of antimony; the common stereotype metal being but one part of antimony with six of lead; and in other proportions it forms the alloy on which music is

engraved. Many antimonial compounds are employed in pharmacy, as tartar emetic, James's powder, &c., and from some of these medicinal preparations having disordered the inhabitants of a monastery, the metal is said to have derived its name (*anti-monk*) antimony.

*Antimony Cup.*—When wine was allowed to stand in these cups, tartarized antimony (*emetic tartar*) was formed and dissolved, and consequently when the wine was drunk it produced sickness.

*Gilt Copper Cup* obtained from the copper mine of Herrngrund, in Hungary. In "*An Account given by Dr. Edward Brown concerning the Copper Mine at Herrn-ground in Hungary,*" the following description occurs:

"There are also two springs of a vitriol water, which are affirmed to turn iron into copper. They are called the old and the new *ziment*. These springs lie deep in the mine. The iron is ordinarily left in the water 14 days. I here present you with some pieces of it, and with a heart and chain, formerly iron, but now appearing to be copper. Divers of these pieces I took out of the old *ziment*. They are hard within the water, and do not totally lose their figure, and fall into powder, as you will perceive by them; they will easily melt. I have sent a piece melted without the addition of any other substance. They make handsome cups and vessels out of this salt of copper. I drank out of one of them when I was at the *Verwalter of Herrn-ground*, his house. It was gilded over, and had a rich piece of silver ore fastened in the middle of it, and this inscription engraved on the outside:—

"*Eisen war Ich, Kupfer bin Ich;  
Silber trag Ich, Gold bedeckt mich.  
Copper I am, but Iron was of old;  
Silver I carry, cover'd am with gold.*"

Phil. Trans. Vol. 5. 1670.

If iron is placed in a solution of sulphate of copper, the iron is dissolved as sulphate of iron, and copper takes its place. This process is termed *cementation*, and the cups exhibited are thus produced. The inscription on the cup is *Gott zeigt an Mir sein grose Macht der auss Eisen Kupfer Macht*, "God shows in me his great power, who out of iron makes copper." The date of this cup is about 1650.

**BISMUTH.**—The ready fusibility of this metal renders its metallurgical treatment exceedingly simple, the metal being readily separated from any foreign matters by fusion. Some singularly beautiful examples of bismuth, crystallized artificially, are introduced. The iridescence is given to the surface by the regulated action of heat. Bismuth is used in the formation of *type metal*, *pewter*, *solder*, and *fusible metal*. An alloy of bismuth 8, lead 5, and tin 3, will melt at a temperature less than that of boiling water.

**CADMIUM.**—This somewhat rare metal is extracted from the zinc smelted from cadmiferous blende. Specimens of metallic cadmium are shown in the form of ingot and sheet. The sulphide, known as *Cadmium yellow*, is employed by artists; but the metal has not yet found any important application in the arts.

**TIN PLATE.**—This is sheet iron coated with a thin layer of tin. The iron, which must be manufactured with much care, coke being used, is rolled into sheets of the required thinness. The sheets are cut into rectangular pieces, and these are freed from every particle of adhering oxide, or any impurities which would inevitably prevent the adhesion of the tin. The plates are bent into a saddle or *U* shape,

ranged in a reverberatory oven and heated to redness. They are withdrawn, plunged into an acid bath, and once more exposed to ignition in the furnace, by which they are said to be *sealed*. The plates are passed through iron cylindrical rollers, and then immersed for ten or twelve hours in an acidulous lye, made by fermenting bran water, after which they are exposed to the action of dilute sulphuric acid, until they become perfectly bright. Being cleaned off with bran, the plates are plunged into some melted tin, which is covered on the surface with about four inches of tallow. The plate subsequently is dipped into another pot of metal, called "Wash-pot No. 2," and then cleaned off by the workman. A skilful tin-plater can pass 5,625 plates through his hands in 12 hours.

*Miscellaneous.*—The miscellaneous specimens in this case are too numerous to be described individually. They include some of the rarer metals, such as examples of *thallium* and *indium*—two metals discovered by aid of spectrum analysis, the former in 1861 by Mr. W. Crookes; the latter in 1863 by Professors Reich and Richter of Freiberg in Saxony. Examples of several useful alloys are exhibited, such as *Britannia metal* and *speculum metal*. There are also a few specimens illustrating the application of metallic zinc, but these will be described elsewhere (p. 113).

This concludes our survey of the series of cases and models in the central area of the Museum. Of the remaining cases, Nos. 47 to 52 are described in the metallurgical section (p. 110), and Nos. 58 to 69 in the ceramic and vitreous section (p. 140). Before passing to these, however, it is desirable to call attention to a few miscellaneous specimens distributed through the room according to convenience of space.

#### SUNDRY SPECIMENS.

Commencing on the eastern side we find near the Head of Melpomene, No. 9, several *Querns* or ancient handmills used for grinding corn. Most of these being formed of a siliceous conglomerate or "pudding-stone," a rough surface is constantly maintained by the unequal wear of the flint pebbles and the cementing substance.

A *Japanese Vase in cloisonné enamel* stands on a pedestal between Wall-cases Nos. 52 and 53. The vase is broken at the shoulder, but this fracture serves to show the method of manufacture, which is described at p. 165. Beneath the vases are some blocks of *hematite* (p. 108), and a large specimen of *cyano-nitride of titanium* (p. 84). Between Cases 46 and 47 will be found a large block of *spathic iron ore* from the Brendon Hills (p. 109), and an *iron-casting* (p. 56). Near Case 42 is a fine *Flemish Monumental Brass*. This brass forms part of the mixed-metal series exhibited. It is of Lodewyc Cortewille, of Cortewille, near Liège, who died in 1504, and of his wife Colyne van Castre, who died 1496. The analysis made in this establishment shows its composition to be—Copper, 64·0; Zinc, 29·5; Lead, 3·5; Tin, 3·0.

On the model of the Sheffield Steelworks, at the northern end of the room, will be found the *ancient bronze dish for measuring lead*, described at p. 107. Near Case 14 the wall-space is occupied by an *electrotype* (p. 71), and a fine *iron-casting* of Leonardo da Vinci's "Last Supper" (p. 56). Some beautiful *electrotypes cast in elastic moulds* are hung between the embayments on this side of the room. An *ancient coat of mail*, showing the method of riveting the steel links, will be found here; and an *ancient bronze Greek tripod* stands near. Some *mosaics* (p. 165) are placed on the staircases leading to

the galleries, and here will also be found *six water-colour sketches* illustrating geological scenery. Several *maps selected to illustrate the progress of the Geological Survey* are suspended beneath the first gallery, and can be drawn down when necessary for reference. There is also a copy of *William Smith's first large geological map of England and Wales*, published in 1819. By comparing this with *Greenough's map* published by the Geological Society in 1865, a copy of which hangs on the opposite side of the room, it will be seen that the broad features of the geological structure of England were laid down, with remarkable accuracy, by the "Father of English Geology."

### THE MINERAL COLLECTION.

The Mineral Collection of this Museum is arranged in the series of 56 wall-cases around the principal floor, and in the large horse-shoe case occupying a prominent position in the central area. Apart from this general collection, there will be found on the same floor a few mineral specimens, which have been isolated on account either of their size or of some special interest attaching to them. As each specimen is distinctly labelled, and moreover as a special catalogue of the minerals is published, it will only be necessary in the present guide to give such a popular description of the collection as shall render it intelligible and interesting to the general visitor.

The so-called *non-metallic minerals* occupy the central horse-shoe case, and are described at p. 121; while the *Ores* or *Metalliferous minerals* are placed in the series of wall-cases, and arranged in the following order:—

British ores (west side)	- -	Cases 1 to 14, p. 79.
British ores (east side)	- -	„ 43 „ 56, „ 106.
Foreign ores	- -	„ 15 „ 23, „ 87.
Colonial minerals	- -	„ 37 „ 42, „ 101.
Mineral veins	- -	„ 24 „ 36, „ 97.

Each of these sections of the collection will now be brought separately under notice.

### BRITISH ORES. 1st Division. WESTERN SIDE. Wall-cases 1 to 14. COPPER.

Case 1.—Although there is evidence that copper ores were worked in Anglesey by the Romans, yet the copper mines of this country are not as a rule of ancient date. In the time of Elizabeth there was an Act of Parliament forbidding the exportation of calamine, as retaining it may occasion *large quantities of rough copper to be brought in* for the manufacture of brass, latten, bell-metal, pan-metal, and shrof-metal. A century since, several tin mines were abandoned when the miners came to the *yellowes*; this was the yellow copper ore, and their saying was that the "*yellowes cut out the tin*." This shows the small estimation in which copper ore was then held. In 1874 there were in Cornwall and Devon about 92 mines selling copper ore at the public sales—"ticketings." These are so called from the circumstance that the sale is conducted in silence; the ore for sale is announced, and the bidders write the price they offer on a *ticket*, which is folded up and silently put into a glass. The *Clerk of the ticketings* opens these and proclaims who is the highest bidder.

The accounts of these sales are published in "ticketing papers." The value of all the ores has been previously determined by the assay of *samples*, one pound in weight, which are taken by all the parties concerned from the heaps prepared for sale at the mine.

The series of copper-producing minerals exhibited in this collection commences with the valuable *Native, virgin, or malleable copper*. In many of the Cornish mines this mineral is not unfrequently found in company with various copper ores; the largest masses occurring in the serpentine of the Lizard district, of which a magnificent example will be seen in the hall (No. 175, p. 47). The Irish and Scotch specimens on the top shelf of case 1 show its occurrence in thin plates in the fissures of trap-rock; whilst many other examples in the same case exhibit the characters of the crystallized varieties.

From native copper we pass to the sub oxide known as *Cuprite* or *red copper ore*, a mineral containing nearly 90 per cent. of copper. It occurs often in octahedral or eight-sided\* crystals, of a fine ruby colour and high lustre, and occasionally assumes delicate capillary or hair-like forms, known to the miner as "*plush copper ore*," and to the mineralogist as *Chalcotrichite*; whilst the less pure brick-red massive varieties of cuprite are often distinguished as *tile ore*. *Melaconite* or *black oxide of copper*, is a dull blackish mineral substance resulting from the decomposition of other copper ores.

Case 2.—Well known from its employment sometimes for ornamental purposes, and sometimes as a pigment, the beautiful mineral called *Malachite* or *green carbonate of copper*, naturally claims attention. In this country it is found only in subordinate quantity, rarely presenting distinct crystalline forms, but occurring usually in mammillated, botryoidal, and stalactitic masses. Its recent formation is well illustrated by the specimens from Wheal Leisure, in which particles of sand are cemented by this mineral. With these specimens may be noticed the examples of cupriferous sandstone and conglomerate from the Lower Keuper of the neighbourhood of Alderley Edge in Cheshire. The copper is dissolved out by treating the sandstone with hydrochloric acid, and from the solution of chloride of copper thus obtained the metal is precipitated by scrap iron. Among the carbonates of copper will be found a few specimens of *Azurite* or *blue malachite*, and on the same shelf are some samples of *Chrysocolla*, or hydrous silicate of copper.

Among the Cornish arseniates of copper, attention may be directed to the beautiful sky-blue octahedrons of *Liroconite*; the dark blackish-green crystals of *Clinoclase*; the bright emerald-green six-sided plates of *Copper-mica*; the dull green crystals of *Olivenite*, and the fibrous variety of the same species known, from its structure, as *wood arseniate of copper*. The *condurrite* of Dr. Faraday appears to be an impure cupric arsenide. With these are associated some specimens of *Libethenite*, or phosphate of copper, and a sample of the basic sulphate of copper from Cornwall, described by Professor Maskelyne in 1864, under the name of *Langite*. Here also will be found specimens of Professor Church's *Woodwardite*, an uncrystallized mineral of fine blue colour containing sulphate of copper and hydrate of alumina.

From these somewhat rare minerals we turn to the important ore known as *Copper glance*, *vitreous copper*, or *Redruthite*, a disulphide of copper containing 80 per cent. of metal. From St. Ives and St. Just several fine crystallized specimens are exhibited, and in some of them will be recognized the peculiar six-sided forms which have suggested the popular name of "*nail-head copper ore*." The speci-

mens under the glass shade, recently obtained from St. Ives, are especially noteworthy.

Cases 3, 4, 5, 6.—Far exceeding all other copper ores in its importance to this country is the well-known *copper pyrites*,—the *yellow ore* of the miner, and the *Chalcopyrite* or *Towanite* of the mineralogist. This mineral, which is a sulphide of iron and copper, is usually found massive, but it occasionally occurs crystallized, its characteristic forms being well shown by the specimens in Cases 3 and 4. The fine mammillated and botryoidal masses from Cornwall and Devon are known to the miners as "*blister ore*"; whilst the iridescent tarnish on the surface of other varieties of copper pyrites has suggested the name of "*peacock ore*."

In this country copper ore is obtained from the mines of Cornwall and Devonshire, from some mines in Ireland, a few in Wales, and some in the northern counties. Each of these localities has its representatives in the collection, and the produce of the several mines will be found in the "*Mineral Statistics*" compiled by the author of this Guide.

Case 7.—Allied in chemical composition to copper pyrites, with which, indeed, it was long confounded, is the species called *Bornite*, *purple copper ore*, or *erubescite*. To our Cornish miners the mineral is commonly known as "*horse-flesh ore*," whilst frequently it passes under its German name of *Buntkupfererz* (variegated copper ore). In addition to the fine purple masses from Ireland and Cornwall, there will be found several crystallized specimens exhibiting its cubic forms; these crystallized varieties are exclusively British, being confined to the mines in the neighbourhood of Redruth.

The crystallized specimens of the rare Cornish mineral *Tennantite*—a sulphide of copper, iron, and arsenic, of somewhat rare occurrence—are followed by those of *Fahlerz*, or *grey copper ore*, a species which, although uncommon in this country, occurs near Liskeard in fine crystals, which exhibit well the characteristic tetrahedral forms which have gained for this mineral the name of *Tetrahedrite*. The series of copper ores is brought to a conclusion by the specimens of *Endellionite* or *bourmonite*, an antimonial sulphide of copper and lead, of which some magnificent crystals of well-defined rhombic form, and remarkably high lustre, are exhibited from Liskeard in East Cornwall.

## TIN.

Case 8.—From the earliest recorded times Britain has been famous for its tin. From Cornwall the Phœnician navigators took this metal to Tyre and Sidon; and, in all probability, the bronzes of Assyria and of Egypt were made with the tin raised by the ancient Britons. The Cassiterides, or Tin islands of the historian, have been thought to be the Scilly islands; but as there is no evidence that any tin was ever found in Scilly, and certainly there is none there at present, this idea must be relinquished. In all probability the name was given by the early navigators to the western part of England, over which the tin formations are spread, and where we find evidences of mine-workings of the highest antiquity.

Diodorus Siculus describes the trade with Cornwall, "*Bolerion*," for tin, and mentions the place of shipment,—the Ictis, an island adjoining to Britain. He says, "It is something peculiar that happens to the islands in these parts, lying between Europe and Britain; for at full-tide, the intervening passage being overflowed, they appear islands; but when the sea returns a space is left dry, and they are seen as peninsulas." Mr. Wright and the late Sir G. C. Lewis

suppose the Isle of Wight to be the Ictis, but it does not fulfil any of the conditions of the geographer; whereas St. Michael's Mount and Looe Island in all respects agree with the description. Diodorus evidently speaks of more than one island, and there is abundant evidence to show that both St. Michael's Mount and Looe Island would have been convenient shipping ports for the tin raised around the Mount's Bay and Land's End, and for that obtained from the old tin mines around St. Austell.

The produce of tin in Cornwall, for more than a century, observed a remarkable constancy. In 1750 about 2,000 tons were produced; this rose to above 3,000 in 1817; to more than 4,000 tons in 1827; and it oscillated between 3,000 and 4,000 until 1841. In 1874 the quantity of tin ore or "*black tin*" raised amounted to 14,715 tons, producing 9,724 tons of metallic or "*white tin*." In spite, however, of this high produce, British tin mining is at present in a most unsatisfactory condition, owing in great measure to the recent discoveries of enormous deposits of tin ore in Australia.

Tin is almost exclusively obtained from *Cassiterite* or *tin-stone*, a peroxide of tin containing nearly 80 per cent. of metal. In the granite and clay-slate of Cornwall and West Devon this mineral occurs in veins, and is readily separated from its gangue and from most of its accompanying minerals, by taking advantage of the great density of the ore. With the specimens of tin-stone will be found a very curious set of pseudomorphous crystals, or those which have the composition of one mineral and the form of another, in which the original felspar of a porphyritic granite has been removed, and the oxide of tin has taken its place, preserving still the true felspar form. The subject will again be referred to at p. 100.

During the lapse of long geological periods the stanniferous or tin-bearing rocks have been worn down by the combined influences of air and water, and the contents of the mineral lodes have been carried down to the lower grounds, and arranged in obedience to the laws of gravitation. Tin was thus deposited in beds over the underlying rocks in the valleys, being covered up to various depths with lighter matter. Specimens of such *stream tin* are exhibited from several Cornish localities, and with them are some examples of the fibrous varieties of tin-stone, known from their peculiar structure as "*wood tin*," and *toad's-eye tin*." "*Streaming*," or washing these deposits for tin, is now nearly extinct.

Case 9.—On the first shelf of this case are placed several samples of *Stannine*, known also as *tin pyrites* and *bell-metal ore*; a mineral containing sulphur, tin, copper, iron, and frequently zinc. This mineral is confined in Cornwall to a few localities, where it has been raised as a tin ore to a limited extent.

#### BISMUTH.

Case 9.—This metal, which occurs usually in a native or free state, is not found in this country in any considerable quantity. In Cornwall its ores occasionally occur associated with other minerals,—with tin in St. Just, and with copper in Redruth and in the Camborne mines. A small quantity is raised at East Pool Mine.

In addition to the samples of *Native bismuth*, of which some are remarkable for their brilliant lustre, will be found several specimens of *Bismuthine*, a tersulphide of bismuth; and of the rare mineral called *Aikenite* or *needle ore*, a sulphide of bismuth, copper, and lead. It is noticeable that bismuth and its ores are characterized by their extreme fusibility, melting readily even in the flame of a candle.

## COBALT AND NICKEL.

Case 9.—The ores of these allied metals will be more fully noticed among the foreign minerals. In this country they are occasionally found in Cornwall, Cumberland, and Scotland, but the amount is neither considerable nor constant. Cobalt was formerly raised at Huel Sparnon, near Redruth, and at Dolcoath, near Camborne; it has also been discovered in St. Just, to the west of Penzance, and has for some years been sold from the St. Austell Consols. At Coniston, in Cumberland, fine specimens of cobalt ore occur; and from the property of the Duke of Argyle, in Argyleshire, nickeliforous pyrites in some quantity was raised a few years since. In 1854 the St. Austell Consols sold no less than 79 tons of nickel and cobalt ore, but at present neither of the minerals is raised.

The principal cobalt ores are *Smaltine*, or tin-white cobalt, and *Cobaltine*, or silver-white cobalt; the former an arsenide, and the latter an arsenio-sulphide of cobalt, but both usually containing varying proportions of other metals. The decomposition of these arsenical cobalt ores produces the peach-blossom coloured arseniate known as *Erythrine* or *cobalt bloom*.

Among the nickel ores, of which the principal is the di-arsenide known as *Kupfernickel* or *copper nickel*, attention may be directed to the delicate needle-like crystals of *Millerite* or *capillary pyrites*,—a sulphide of nickel occurring in the cavities of the clay-ironstone nodules of South Wales.

## TUNGSTEN.

Case 9.—This metal, known also as *wolframium*, occurs usually as a double tungstate of iron and manganese, forming the species called *Wolfram*. Having a density corresponding nearly with that of tin-stone, it is with difficulty separated from the tin ore with which it is almost invariably associated. Oxland's process for dressing tin ores containing wolfram will be subsequently noticed (p. 112). 32 tons of wolfram were raised at East Pool Mine in 1874. The yellow mineral called *Wolframine* is a tungsten ochre: whilst the rare species *Scheelite* is a tungstate of lime.

Cases 10 and 11 are occupied by metallurgical products which will be noticed under the head of "Tin smelting" (p. 112).

## ZINC ORES.

Case 12.—The most widely-diffused ore of this metal is the sulphide called *Zinc blende*, from the German *blenden*, to dazzle, in allusion to the high lustre which this species often presents, and which is well seen on the cleavage-faces of some of the specimens here exhibited. Blende is generally associated with the ores of lead, and frequently with those of copper and tin. In a state of purity it is transparent and almost colourless, as seen in some of the specimens in this case; but generally the blende of this country is mixed with a variable amount of sulphide of iron, which imparts to it a dark colour, whence it is called by the English miners *Black Jack*. In some districts the presence of zinc is deemed by the miners unfavourable, and they speak of "Black Jack cutting out the lode." In others it is thought to be a favourable indication, and we often hear that "Black Jack rides a good horse."

More valuable as an ore, but much less abundant than the sulphide, is the carbonate of zinc known usually as *calamine*. This mineral rarely occurs crystallized, but is usually found in deposits of mammillated, botryoidal, and stalactitic forms, of which some fine examples are exhibited from Alston Moor.

The hydrous silicate of zinc, known as *Smithsonite* or *electric calamine*, commonly occurs associated with the carbonate, with which it is not unfrequently confounded. Attention may be directed to a fine specimen of a blue cupreous variety of this species from Cumberland.

#### CADMIUM.

Case 12.—With the ores of zinc will be found some specimens of the rare and exclusively Scotch mineral *Greenockite*, a sulphide of cadmium occurring in yellow lustrous crystals of hexagonal form. The usual sources of cadmium and its applications have been noticed at p. 77.

#### MANGANESE.

Case 13.—Although not occurring in this country in regular deposits or in very considerable quantity, the ores of manganese have, however, been worked in several localities, especially at Lifton, near Tavistock, and at Launceston, at several mines not far from Exeter, in the Mendip hills, and in Warwickshire.

In 1874 the mines of Cornwall, Devon, and Cardiganshire yielded 5,778 tons of manganese ore.

Manganese is employed in glass manufacture as a decolouring agent, in the manufacture of pottery as a pigment, and it is likewise used in the manufacture of *Spiegeleisen*; but its great use is in the preparation of chloride of lime and in bleaching establishments; it is employed in both cases for the purpose of liberating the chlorine from the hydrochloric acid or the salt (chloride of sodium) with which it is mixed for this purpose.

*Pyrolusite*, or binoxide of manganese, has received its name from *πῦρ* (*pur*) fire, and *λῶς* (*luō*) to wash, in allusion to its employment as a decolouring agent in glass manufacture, and for the same reason it is called by the French glass makers *le savon des verriers*.

*Manganite*, or grey manganese ore, is a hydrous sesquioxide, of much rarer occurrence in this country than *pyrolusite*; whilst the somewhat ill-defined species *Psilomelane* is an impure hydrous oxide, usually found in botryoidal or stalactitic forms, which from their smooth surface and black colour have given the name to this species.

#### URANIUM.

Case 13.—Of this rare metal several ores are here exhibited. The oxide called *Pitchblende* is interesting as being the mineral in which uranium was first detected; whilst the species called *Chalcolite* and *uranite* are attractive by the brilliant colours of their crystals; the former of these minerals contains phosphate of copper, and the latter phosphate of lime, associated in both cases with a phosphate of uranium.

Some splendid specimens of *chalcolite*, recently found in Cornwall, are exhibited.

#### TITANIUM.

Case 13.—In the hearths of some of the iron furnaces of South Wales, and elsewhere, there are frequently found beautiful crystals of a peculiar compound of titanium derived from the ores with which the furnaces are fed (*see* p. 73). But although recent researches have shown that titanium is a metal much more widely diffused than was formerly supposed, the distinct native compounds of this element are, nevertheless, far from numerous. In

the state of oxide, titanium occurs in three totally distinct forms, of which specimens are here exhibited. The long prisms of *Rutile* running through the quartz of Perthshire, the fine tabular crystals of *Brookite*, associated with albite-felspar, near Tremadoc, and the small pyramidal crystals of *Anatase*, are simply different forms of the same oxide of titanium; the chemical composition being in all cases identical.

Titanium has been employed for improving the quality of iron and steel, and for the preparation of certain pigments.

#### VANADIUM.

Case 13.—The vanadate of lead called *Vanadinite*, found not unfrequently in the lead mines of Wanlock Head in Dumfriesshire, will be again noticed among the lead ores (p. 108). Vanadium has been found in the copper-bearing sandstone of Alderley Edge in Cheshire, and appears indeed to enjoy a much wider diffusion than was formerly supposed.

#### MOLYBDENUM.

Case 13.—The chief source of this rare metal is the mineral called *Molybdenite*, a sulphide of molybdenum, somewhat resembling plumbago in appearance. Specimens are exhibited from Perthshire, and from the syenitic rocks of Charnwood Forest in Leicestershire.

#### CHROMIUM.

Case 13.—This metal is tolerably abundant in the form of chromate of iron, constituting the mineral called *Chromite* or *chrome iron ore*. It usually occurs in serpentinous rocks, and is especially abundant in the serpentine of the Shetland Isles, which has yielded several of the specimens here exhibited. The compounds of chromium are extensively employed in the arts, principally in the preparation of pigments.

#### ANTIMONY.

Case 14.—At one period considerable quantities of antimony ore were raised in Cornwall, and some in Dumfriesshire; but now the principal part of our supply of antimony is from Borneo and the East Indies.

The chief ore is the tersulphide of antimony, called indifferently *Antimonite*, *stibnite*, and *antimony glance*. By the side of the samples of this ore are a few specimens of *Jamesonite*, a sulphide of antimony and lead, of which enormous lodes occur in Devonshire; but the difficulty of separating the lead and antimony from each other renders them valueless.

By the decomposition of jamesonite is produced the yellow antimoniate of lead called *Bleiniere*.

#### BRITISH GOLD.

Case 13.—There is no metal found more widely diffused than gold, but it has rarely been found in these islands in sufficient quantities to render the search for it remunerative.

In the tin streams of Cornwall gold has been and is still found. The *streamers* occasionally detect small particles of gold associated with the tin ore, which they pick out and preserve in a quill. Occasionally a moderate-sized piece of gold has been discovered. One fine specimen from Carnon stream is in this collection, and also some of the smaller grains. Gold has been found in Devonshire, near North Molton, and attempts have been made from time to time

to work mines supposed to produce it. In every such attempt, however, the result has been the total loss of the money invested.

There is abundant evidence to show that the Romans actually worked gold in Wales; and Carmarthenshire and Cardiganshire have at various times yielded small quantities of the precious metal. During the last quarter of a century, however, public attention has, from time to time, been directed to the gold-bearing district of Merionethshire. The excitement which a few years back attended the workings at the Vigra and Clogau, between Dolgelly and Barmouth, led to the opening up of numerous other gold mines in adjacent districts, but the operations were ultimately abandoned as unremunerative. In 1874, however, workings at the Vigra and Clogau were re-opened, and 385 ozs. of gold were raised. The gold-mining was at one time prosecuted with such vigour that in 1862 the Welsh hills yielded, according to official returns, as much as 5,299 ounces of gold, valued at 20,390*l*.

Among the specimens in the case before us are several examples of native gold from Wicklow, the discovery of which in the last century produced considerable excitement.

In 1795 lumps of pure gold were picked up in a valley on the flank of the mountain called Croghan Kinshela; and as the natural consequence of such a discovery, crowds of the country people quitted their ordinary avocations and rushed to the gold streams of Wicklow. During six weeks some hundreds of gold seekers appear to have collected a considerable quantity of the precious metal. Then a commission, consisting of Messrs. Mills, King, and Weaver, directed the operations of streaming, and until the outbreak of the rebellion in May 1798, the works appear to have been remunerative. When in 1801 these works were again brought into active operation, not only was the process of "streaming" still pursued, but an attempt was made to discover the lodes from which the gold had been derived. A level was driven 178 fathoms into the heart of the mountain, and the *costeaning*\* trenches were dug for thousands of fathoms in length, yet not a particle of gold *in situ* ever rewarded this patient labour. The operations were for some time continued on the alluvial deposits. Having raised 944 ounces of gold, the ingots from which were from 21½ to 27½ carats fine, the alloy being silver, and the total value being 3,675*l*., the Government were advised to abandon the works.—*On the Mines of Wicklow and Wexford, by Warrington W. Smith, M.A., &c.*

Gold has also been found and worked from a very early period in Scotland. Scotch gold is mentioned as early as the year 1125 in a grant made by King David I.; and Pennant says: "In the reign of James IV. and V. of Scotland, vast wealth was procured in the Lead Hills, from the gold found in the sands washed from the mountains; in the reign of the latter not less than to the value of 300,000*l*. sterling." This is evidently the exaggerated report of some parties who were desirous in Pennant's time, as they have been since, of reviving the search. The Bannatyne Club published in 1825 a curious manuscript, "*The Discoverie and Historie of the Gold Mines in Scotland, written in the year 1619, by Stephen Atkinson,*" of which a copy is in the library of the Institution. In this work several districts are named over which gold has been discovered,

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\* *Costeaning*, from the old Cornish *cothas-stea*n, fallen or dropped tin. It signifies to sink pits in the search of lodes transversely to the supposed direction of these lodes.

and many statements, evidently the exaggerated dream of a sanguine projector, are made to convince the King, who is compared to King Solomon for wisdom, that public money might be spent with advantage in the search. Gold is still found in the Crawford Moor district, and an interesting specimen of auriferous quartz was discovered at Wanlockhead in Dumfriesshire in 1872.

In 1867 public attention was directed to the occurrence of gold in Sutherland, and considerable excitement prevailed during the succeeding two or three years. Large numbers of miners were attracted to the diggings, and in 1868 as much as 577 ounces of gold were returned from Helmsdale. The value of this gold was about 2,000*l.*; but the yield was not kept up, and the workings were soon abandoned. Several specimens of Sutherland gold are exhibited, and with them is placed a model of a nugget weighing 2 ozs. 17 dwts. found at Kil-Donnan in April 1869.

#### SILVER.

Case 13.—Silver ores do not occur in any large quantity in this country. True, we obtain annually a large amount of silver from our lead ores, but this will be noticed in a future section (p. 116).

*Native silver, silver glance, red silver ore, and horn silver* are exhibited from several of our Cornish mines, but it seems desirable to defer notice of these minerals until describing the more typical specimens from foreign localities (p. 93).

A series of ores is exhibited from the little isle of Sark, where silver mines were for some time worked; but not being sufficiently remunerative, the operations were at length discontinued.

#### ARSENIC.

Case 13.—In the lower part of this case are several specimens of *Mispickel* or *arsenical iron pyrites*, an arsenio-sulphide of iron frequently found in our western mines, and commonly employed as a source of "white arsenic," the preparation of which will be subsequently described. (See p. 115.)

With this series terminates the first division of the British ores, the remaining section,—including the ores of lead and iron,—being arranged in the recesses on the opposite side of the room. As, however, it appears desirable to continue the description of the wall-cases in their natural sequence, the collection of foreign ores occupying the cases adjacent to those just described will now be brought under notice, whilst the description of the second division of British metallic minerals will be reserved until reaching the opposite side of the Museum. (See p. 106.)

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### FOREIGN ORES. Wall-cases 15 to 23.

#### COPPER.

Case 15.—Among the specimens of *Native copper* which head the series of copper-bearing minerals, attention may be especially directed to the fine samples from the remarkable deposits around Lake Superior. There exists abundant evidence to show that these deposits were worked at a very remote period; and one of the stone hammers used by the primitive miners will be found in Case 15. All tradition, however, of these early workings had been lost, and the existence of the metal was known only by the occurrence of

masses of copper on the shores of the lake. In 1845 operations were commenced at the Cliff Mine, and these were rapidly followed by the opening up of numerous other workings. The copper-lands on the south side of the lake,—including the Keeweenaw Point, Portage, and Ontonagon districts,—consist of Lower Silurian sandstones and conglomerates, with a central belt of trap-rocks traversed by copper-bearing veins. The metal is also found disseminated through the beds of trap, and occasionally through the sandstones and conglomerates; and it likewise occurs in contact deposits between the trap and the neighbouring rocks. The chief portion of the copper is native, and occasionally, from the manner in which this is mixed with quartz and carbonate of lime, large masses are broken out with tolerable ease; but when, as is frequently the case, a mass of several feet in thickness presents itself, there is no mode of extricating it from the rock but by the slow process of cutting it with cold chisels. This native copper contains a considerable proportion of silver; in some specimens the silver crystallizes about the copper in a very beautiful manner. The two metals do not in general occur alloyed with each other, but the silver is scattered through the copper in such a manner that each metal remains chemically distinct from the other. (*See specimens in case 22.*) Copper also occurs at the Lake Superior mines in the form of oxide, silicate, sulphide, and arsenide.

While studying the specimens in the case before us, attention should also be directed to a series from this locality presented by Mr. Bauerman, and placed in case 36.

In addition to the Lake Superior series, there are exhibited other specimens of native copper, from the mines of Russia, Tuscany, Cuba, and Chile; whilst of the valuable ore *Cuprite* or *red oxide of copper*, samples are exhibited from several localities in Russia, and from Rhenish Prussia, Hungary, Cuba, and South America. The detached crystals of cuprite from old workings at Chessy, near Lyons, are notable for their large size and perfect form, but the mineral is disguised by a thin coating of green carbonate.

Case 16.—The greater part of this case is occupied by specimens of the beautiful mineral *Malachite* or *green carbonate of copper*, of which the celebrated Russian deposits have contributed numerous fine examples. The richest masses of malachite have been found about 100 miles south of Bogoslovsk. Some idea of the magnitude of the masses in which malachite sometimes occurs may be formed from Sir R. Murchison's account of a lump discovered at Nijny Tagilsk, at a depth of 280 feet:—"The strings of green copper ore occurring at intervals were followed downwards, when, increasing in width and value, they were found to terminate at the base of the present mines in an immense irregular-shaped botryoidal mass of solid malachite, the base of which had not been reached." The summit of this mass is described as being 18 feet long and 9 feet wide. When Murchison visited it in 1843, it was calculated to contain not less than half a million of pounds weight of pure and solid malachite. On the formation of this malachite Murchison has some appropriate remarks, which apply with equal force to the carbonates of copper that occur in South Australia:—

"The geological interest attached to this mass (the above named) lies in the indication it affords, that the substance called malachite has been formed by a cupriferous solution which has successively deposited its residue in a stalagmitic form. *Mutatis mutandis*, this mass has only to be viewed as formed of calcareous spar, and it presents every one of the features so well known to those who have

examined stalactitic grottoes, with their stalagmitic floors, in the clefts and caverns of limestone, or still more those large masses of tufa, which have proceeded from calcareous wells. Whenever a portion of the malachite has been broken off, the interior is seen to consist of a number of fine laminae (a fasciculus of radio-concentric globules), which invariably arrange themselves equally around the centre on which they have been formed, and are adapted to every sinuosity of the pre-existing layer; here presenting a dark line—there a bright and light one, just as the solution of the moment, the day or the hour, happened to be more or less impregnated with colouring matter. Besides round concretions, sometimes almost spherical, and also depressions of the surface, the under sides of this malachite are singularly analogous to that of any large mass of calcareous tufa, in presenting pendant finger-shaped stalactites, which are also composed of concentric laminae. The external surfaces of these concretions are frequently covered with a black ore of manganese, which usually falls off on being touched. \* \* \* On the whole we are disposed to view it as having resulted from copper solutions emanating from all the porous, loose, surrounding mass; and which, trickling through it to the lowest cavity upon the subjacent rock, have in a series of ages produced this wonderful subterranean incrustation.”—*The Geology of Russia*, p. 374.

Passing from the green to the blue carbonate of copper, attention may be invited to the groups of finely-formed brilliant crystals from the now exhausted copper mines of Chessy, about 20 miles N.W. of Lyons: from this famous locality the species has received the name of *Chessylite*.

The dark blackish-green crystals of *Libethenite*, a hydrous phosphate of copper, and the bright emerald-green *Euchroite*, a hydrous arseniate of copper, both from Libethen in Hungary, are placed by the side of some fine mammillated specimens of the cupreous phosphate called *Ehlite*, and a sample of the rare Russian mineral *Demidovite*, a siliceous phosphate of copper.

The mineral called *Atacamite*, from the desert of Atacama between Peru and Chile, is an oxychloride of copper occasionally found in sufficient quantity to be worked as an ore, and occurring also as a volcanic product on certain Vesuvian lavas.

In the lower part of this case are some fine specimens of *Copper glance* and *bornite* or *purple copper ore*, from the remarkable deposits of Monte Catini in Tuscany. These minerals occur, with other copper ores, in the form of nodules and irregular masses embedded in a steatitic matrix in a dyke of tertiary serpentine, or *gabbro verde* associated with the metamorphic rock called *gabbro rosso*. The principal part of the ores from the prosperous mine of Monte Catini is smelted at Briglia, near Prato.

Case 17.—On the upper shelves of this case are examples of *Copper glance* and *purple ore* from various localities, the fine masses of purple copper from Chile being especially noteworthy. A large sample of bornite from Greenland is placed in the hall, No. 31.

The important German deposit of *Kupferschiefer*, or copper-slate, is represented by several specimens. This remarkable stratum lying at the base of the Zechstein, or magnesian limestone, extends uninterruptedly over a very wide area, and in spite of its thinness and its poverty of ore is successfully worked at several points, especially at Mansfeld in Prussian Saxony. Occasionally the cupreous schist contains the fossil remains of Permian fish, and a fine specimen of one of the most common species of *Palaemoniscus* is here exhibited. The metallurgical treatment of the Kupferschiefer will be subsequently noticed. (See p. 111.)

## IRON.

Case 18.—The series of iron ores commences with several specimens of *Magnetite*, or *magnetic iron ore*, from the hills of Blagodät in the North Ural; but the most interesting samples of this mineral are those from the famous iron mines of Sweden. "The region of the mines"—so called in Sweden—occupies the whole breadth of the country from the boundary of Norway to the Gulf of Bothnia, its northern boundary being a line drawn from Glommen through Lake Liljan to Soderham, its southern boundary lying about lat. 59° N. The area of this district is 16,000 square miles. The best iron is obtained from the Dannemora mines in Upsala Lin, of which upwards of 3,000 tons are annually received into England, and employed at Sheffield and other places for making steel. The Dannemora mines are three in number, very distinct and parallel to each other; they are explored through a length of more than 1,500 yards, and to a depth of about 80 yards. The annual produce of the Dannemora mines is about 25,000 tons of ore. For a description of Swedish iron-smelting, see p. 60.

The series of iron ores is interrupted by a small number of *titanium* minerals, among which may be noticed the unusually large crystals of *Rutile* from the United States; the splendid crystal of *Arkansite*, a variety of *Brookite* from Arkansas, U.S.; and little square octahedra of *Anatase* from the Grisons. Some fine crystals of *Sphene*, a silicate of lime and titanium, are also worthy of notice.

Returning to the iron-producing minerals, we find several shelves occupied by examples of the different varieties of *Hæmatite* or *red iron ore*. Among these the eye will be especially attracted by the brilliant lustre, and in many cases by the iridescent tarnish, of the crystallized variety called *specular iron ore*, of which the Isle of Elba has contributed some beautiful examples. The Elban specular ore, celebrated from remote antiquity, occurs in enormous deposits on the eastern side of the island, where it has long been worked by large open excavations, principally at Rio; whilst the rich veins of *magnetic ore* associated with hæmatite at the famous Loadstone Mountain, or Monte Calamita, have recently invited exploration. The occurrence of specular iron ore in the craters of volcanoes has been noticed at p. 68.

Case 19.—*Limonite*, *brown iron ore* or *hydrous peroxide of iron*, occasionally called "*brown hæmatite*," is a very abundant and widely-diffused mineral, resulting frequently from the decomposition of other iron ores, and often associated with the ores of manganese. The fine stalactitic and botryoidal forms of the Russian specimens, and the fibrous structure of many of the German samples, sufficiently show the characters of the purer varieties; whilst the friable earthy forms passing into ochre are illustrated by examples from various localities. The pure crystallized hydrous sesqui-oxide of iron, of definite composition, has been separated as a distinct species under the name of *Göthite*, a name introduced by German mineralogists in honour of their great poet and philosopher.

The *bog iron ore* is an interesting variety of limonite formed in low marshy ground from the decomposition of other iron ores. It always contains a large proportion of impurities, phosphoric acid being often present to a considerable extent. The *lake ores* of Sweden, Norway, and Finland, are concretionary forms of brown iron ore formed at the bottom of shallow lakes, whence they are obtained by dredging.

Brown iron ore appears in many cases to have resulted from the alteration of the carbonate of iron, to which species we now pass.

This valuable mineral, called indifferently *Spathose iron ore*, *chalybite*, *siderite*, and *sparry iron ore*, frequently occurs crystallized in rhombohedral forms, which commonly present curved faces, well seen in the fine specimen from Dauphiné; whilst the large crystals from Hüttenberg in Carinthia exhibit the change of this mineral into brown iron ore by the elimination of carbonic acid and the absorption of oxygen and water. Immense beds of spathose ore are found in Styria, forming the outer part of the Erzberg, a mountain from which it was probably dug by the Romans. In Carinthia an excellent ore of this kind exists, from which iron and steel of the first quality are produced. Valuable deposits of spathose ore occur in the Devonian rocks in the neighbourhood of Siegen in Rhenish Prussia, including the celebrated Stahlberg, near Müsen, where it has been worked since the fourteenth century. The carbonates of iron are highly valued for the production of pig-metal well suited for conversion into Bessemer steel.

The remainder of this case is occupied by iron ores of far less importance than those already mentioned. Among these may be noticed the Elban silicate of iron, called *Ilvaite* or *lievrite*; the common arsenio-sulphide of iron, or *Mispickel*; and the rarer arsenide of iron, from Reichenstein, termed *Lövingite*, the treatment of which for the separation of gold will be described at p. 115. The large pentagonal dodecahedrons of *Iron pyrites* from Elba, and the fine bronze-coloured crystals of *Pyrrhotine* or *magnetic pyrites*, from Brazil, also deserve attention; and these, with a small collection of *Chrome iron ores*, complete the series.

#### MANGANESE, BISMUTH, &c.

Case 20.—Examples of the rarer oxides of manganese called *Hausmannite* and *Braunite* are placed by the side of the oxides known as *Pyrolusite*, *Manganite*, and *Psilomelane* (p. 84), minerals which are largely raised in Spain, Nassau, Thuringia, and the Hartz. With these oxides are grouped specimens of the pale pink carbonate of manganese called *Diallogite*, or *manganese spar*, and of the rose-red silicate termed *Rhodonite*; whilst the sulphides are represented by samples of *Alabandine* or *manganese blende*, and by a specimen of the rare mineral *Hauerite*, from its only known locality, Kalinka in Hungary.

Mention has already been made at p. 84 of the value of certain oxides of manganese as sources of oxygen in the operations of bleaching and glass-making, for which purposes they are imported in large quantities. The manganese ores are also used in the preparation of *Spiegeleisen*, a variety of cast-iron containing manganese, and used in the Bessemer process of steel-making (p. 59).

The minerals of the somewhat rare metals which follow need but slender description. A few ores of *Bismuth* are introduced, principally from the cobalt mines of Saxony; and with these are grouped samples of *Molybdenite* from Bohemia, Greenland, and Chile: these are followed by some Saxon specimens of the uranium-ore called *Pitchblende*, and by a sample of the peculiar Swedish mineral known as *Cerite*, in which are associated the silicates of the rare metals, cerium, lanthanum, and didymium.

#### TIN.

Case 20.—The tin ores of the continent scarcely come into competition with those of our own country, but enormous quantities of tin are imported from the isles of Banca and Billiton, and from the Malay peninsula. In the small group of foreign tin ores here inter-

calated, will be found some fine crystals of tin-stone from Brittany, and several specimens from the tin mines of the Erzgebirge or Ore Mountains, which separate Saxony from Bohemia; and with these are placed samples from Spain, Russia, Greenland, Brazil, and the United States.

Following the tin ores are some specimens of the tungstate of iron and manganese, called *Wolfram*, a mineral with which the ores of tin are commonly associated; and of the tungstate of lime named *Scheelite*, after the Swedish chemist Scheele.

#### COBALT AND NICKEL.

Case 20.—The group of cobalt and nickel ores presents some interesting specimens, chiefly from the mines of Schneeberg in Saxony and Tunaberg in Sweden. The white cubic crystals of *Smaltine*, with faces frequently curved and fractured; the pale yellow crystals of *Cobaltine*, exhibiting compound forms allied to those of iron pyrites; and the pink crystalline or earthy *Erythrine*, occurring frequently as an incrustation on other ores, are the most prominent among the cobalt minerals; whilst in the group of nickel ores attention may be directed to a small crystallized specimen of *Kupfernickel*, some fine capillary crystals of *Millerite*, a sample of *Breithauptite* or antimonial nickel, and the fine emerald green incrustations of *Texasite* or carbonate of nickel from Pennsylvania: the composition of most of these minerals, and the applications of cobalt and nickel ores, are noticed at pp. 83 and 114.

#### ANTIMONY.

Case 20.—The fine series of antimony minerals commences with some specimens of the native metal, and of its oxides—*Valentinite* and *Senarmontite*. Of the principal antimony ore, called *Antimony glance* or *stibnite*, numerous specimens are exhibited from various localities; those from Hungary being remarkable for their fine crystalline forms, whilst the Borneo samples are interesting as representatives of a very important locality. It will be observed that some of the specimens are invested with a yellow crust of oxide of antimony, whilst others are coated with the reddish oxysulphide called *Kermesite* or *antimony blende*, of which mineral some specimens are exhibited from Bräunsdorf in Saxony, showing well the characteristic tufts of red hair-like crystals.

#### ZINC.

Case 21.—On the top shelf of this case are some fine examples of the exclusively American ores called *Zincite*, or red oxide of zinc, and *Franklinite*, a mineral in which the zinc oxide is associated with the oxides of iron and manganese, and which is valued as an ore of iron rather than of zinc. The preparation of zinc from the New Jersey ores is illustrated in Case 49, whilst the production of *Spiegel-eisen* from the franklinite residues finds illustration in Case 10 (p. 60). The New Jersey specimens are followed by a group of carbonates and silicates of zinc from the celebrated *Vieille Montagne* or *Altenberg* deposits. These mines are situated on part of the Belgian, Prussian, and neutral territories, between the towns of Aix-la-Chapelle and Verviers. The calamine of these deposits has been worked since 1435; but for four centuries it was employed merely as an earth to make brass, as it was not known to contain any metal. It will be remembered that a large mass of this calamine stands in the lower hall (No. 45).

The group of zinc ores is brought to a close by several examples of *Blende*, or sulphide of zinc, of which those from Hungary and Bohemia present fine crystalline forms, whilst other specimens are notable as containing silver.

#### LEAD.

Case 21.—A fuller description of the various minerals from which lead is extracted will be given in the notice of the British series (p.107): the foreign specimens in this case before us are interesting, however, for comparison with our own.

In the group of lead-spar attention should be directed to the fine transparent and well-formed crystals of *Anglesite*, or sulphate of lead, and of *Cerussite*, or carbonate of lead, from the Wheatley mine in Pennsylvania, where they occur in the upper part of rich lead veins coursing N.E. and S.W. in gneissose rocks. Nor must we omit notice of the remarkably brilliant crystals of anglesite which bestud the cavities in the rich galena of Monte Ponì, in the island of Sardinia. Of the phosphate of lead called *Piromorphite* there are exhibited some examples of peculiar hollow crystals from the Wheatley mine, and of fine barrel-shaped crystals from the mines of Nassau. The eye will not fail to be attracted by the brilliant yellow crystals of *Wulfenite* or molybdate of lead, from Utah; and here also will be found some sombre specimens of the same species from the lead mines of Carinthia.

A small group of the somewhat rare antimonio-sulphides of lead is here intercalated, including the species called *Boulangerite*, *Plagionite*, and *Geocronite*; and from these we pass to the most widely diffused ore of lead—its sulphide, call *Galena*, of which mineral a large series of specimens is exhibited, fairly representing the principal lead-producing districts of the continent. France, Spain, Tuscany, Saxony, Hungary, and Russia have each contributed samples, and with these European specimens are placed a few samples from certain mines in Asia and America. The physical characters of this abundant mineral will, perhaps, be better studied among the more varied series from our own mines (see p. 107).

#### SILVER.

Case 22.—Silver ores have been mined for from the earliest recorded periods of man's history. Throughout Spain, France, and Britain it is quite clear that the Romans eagerly searched for this metal, as they have left behind them numerous remains of their mining and smelting operations. The silver mines of Spain were abandoned until within the last forty years; within that period several rich mines of silver have been discovered. The silver mines of Mexico have been much celebrated since the conquest of that country by Cortes in 1519.

The most productive silver mines in the World are those of America,—New Spain, Peru, Mexico, and especially Potosi, as well as the names of some other places, have become almost synonymous with those used to signify precious metal. The greater part of the silver extracted by mining in Peru is found in a species of ore locally called *pacos*: it is a brown oxide of iron, with silver disseminated through its mass in exceedingly minute particles. The ore of Chile is similar, and one vein of it, existing in the Andes, is said to have been traced for a distance of more than 90 miles, having branches running in the adjoining mountains, some of which are known to be 30 miles in length.

Among the most remarkable of the existing silver mines those of *Real del Monte* must be named. These mines have been continuously worked since 1749; but long previously to that date extensive but irregular workings had been carried on.

Silver mines of extraordinary value have recently been developed in the Western States of North America, especially in Nevada, Colorado, and Utah. Perhaps the most important of these discoveries of silver ore are those in the State of Nevada which date from 1859. Workings of enormous value have been opened in the neighbourhood of Virginia City and at other points on the famous Comstock Lode. A model showing the locations on this lode, and in the neighbouring country, stands near the case of silver ores (model No. 25, p. 65). It is reported that during the year ending December 31st, 1875, the Consolidated Virginia Mine alone yielded bullion to the value of 17,000,000 dollars, or 3,400,000*l.* The metal is, however, extremely rich in gold, and it is estimated that 45 per cent. of the value of the bullion is derived from this source. The Director of the United States Mint states that the total production of all the mines on the Comstock Lode during the year 1875 may be estimated at not less than 50,000,000 dollars, equivalent to 10,000,000*l.* But in addition to the workings on this great lode there are important silver mines in other parts of Nevada and in several neighbouring states. The latest statistics of these western mines will be found in the *Report from the select Committee on Depreciation of Silver, 1876.*

Among the silver minerals exhibited in the case before us are some highly interesting specimens of the *native metal*, the fine solid masses from Chile being especially noteworthy. The remarkable association of this metal with native copper in the Lake Superior specimens has already been noticed (p. 88).

Combined with sulphur, either alone or associated with antimony or with arsenic, silver forms a series of beautiful and valuable minerals. Of these the ordinary sulphide called *Argentite, vitreous ore, or silver glance*, is a soft and highly malleable mineral, assuming a series of cubic forms closely related to those of galena. Passing over the rare Saxon mineral *Miargyrite*, we may notice among the antimonio-sulphides of silver the beautiful species called *Pyrargyrite, ruby blende, or dark red silver ore*, of which the Mexican mines have contributed some magnificent hexagonal crystals; whilst from Saxony is exhibited a specimen of *light red silver ore* or *Proustite*, a mineral chemically differing from the last species in containing arsenic in the place of antimony. To the same class of minerals belong *Stephanite, or brittle silver ore*, the rare species called *Fireblende*, and the mineral known as *Polybasite* in which the silver is partially replaced by copper and the antimony by arsenic.

Another group of silver ores is formed by the combination of the metal with chlorine and its allied elements. The chlorides, bromides, and iodides of silver so formed, of which a few specimens are exhibited from the South American mines, are all affected to a greater or less extent by the action of light. It is notable that iodide of silver when heated, instead of expanding, slightly contracts in bulk.

#### GOLD.

Case 23.—The collection of gold ores is headed by several specimens from Russia. In all probability the auriferous tracts of the Uralian mountains were worked over by the Scythians; and the Arimaspi of Herodotus, a people who had but one eye, and who took the gold away by violence from the Griffins, may have been, as

Humboldt suggests, this nomadic people. Gmelin describes the ancient gold works which he discovered in the district; and Murchison speaks of great piles of ancient drift or gravel which have been removed for the extraction of the gold.

Upon the character of the auriferous deposits of Russia Sir Roderick Murchison writes (*Siluria*, p. 443.): "In some spots in which the gold occurs is a heavy clay; in others, it is made up of fragments of quartz veins, chloritic and talcose schist, and greenstone, which lie upon the sides of the hillocks of eruptive rocks. It was from the infilling of one of the gravelly depressions between these elevations, south of Miask, that the largest lump of solid gold was found of which, at that time (1824), there was any record." This "pepita" weighs 96 pounds troy, and is still exhibited in the Museum of the Imperial School of Mines at St. Petersburg. Some small samples of Siberian gold are exhibited in the case before us.

The produce of the various gold-washing and amalgamation works of Russia appears to have been, for many years, about 1,500 poods; the Russian pood being equivalent to about 40 pounds troy, this will be equal to about 60,000 pounds troy. The following extract from the Anniversary Discourse of the President of the Geographical Society, Sir R. Murchison, in 1844, is to the point:—

"In Russia, as in the Brazils, the great mass of the metals is derived from local detritus or alluvia, usually called gold sand, but for which (as far as Russia is concerned) the term shingle would be much more appropriate. With very trifling exceptions, all such auriferous detritus in the Russian empire occur on the eastern side of the Ural. Slightly known, and near Ekaterinburg only, in the days of Pallas, it was not until the reigns of Paul and Alexander that these gold alluvia were found to extend in a certain zone to the north and south of that locality, throughout 5° or 6° of latitude, and that eventually gold was extracted from them to the annual value of about half a million sterling. Notwithstanding the increased exploration of late years, and many researches in the northern and southern portion of this chain, this quantity has been rarely exceeded; and latterly, the alluvia in some tracts being exhausted, it has begun to decrease. The reign of the Emperor Nicholas, has, however, been distinguished by the important discovery, that portions of the great eastern regions of Siberia are highly auriferous, viz., in the governments of Tomsk and Yeniseik, where low ridges, similar to those on the eastern flank of the Ural, and, like them, trending from north to south, appear as offsets from the great east and west chain of the Altai, which separates Siberia from China. And here it is curious to remark that, a very few years ago, this distant region did not afford a third part of the gold which the Ural produced; but, by recent researches, an augmentation so rapid and extraordinary has taken place, that in the last year (1843) the eastern Siberian tracts yielded considerably upwards of two millions and a quarter sterling, raising the total gold produce of the Russian empire to near three millions sterling."

A few specimens have been contributed from the American mines, and it will be remembered that a large mass of auriferous quartz from the Californian workings is placed in the Hall (No. 113), and described at p. 149.

The long-worked gold mines of Hungary and Transylvania are represented by specimens from Schemnitz, Nagy-banya, and Vöröspatak.

The "Gold Coast" of West Africa has long been celebrated for its gold, and a nugget brought from Ashantee at the conclusion of the late war is here exhibited.

## PLATINUM.

Case 23.—The metal platinum was first discovered by Ulloa, a Spanish traveller in America, in the year 1735. It has since been discovered in Columbia, St. Domingo, Borneo, in the sands of the Rhine, California, Canada East, and Russia.

“Though ores of platinum are found in the alluvia of the Ural chain in various parallels of latitude, it is only within the territories of the Demidoff family that they are still worked. After an examination of the greater number of the platinum works belonging to Nijny Tagilsk, all of which lie on the western slope of the Ural-tau in that parallel, M. G. Rose has shown that in one only of the numerous masses of alluvia was any gold mixed with it, and that in no instance could he detect any veinstones of quartz, or other fragments of rocks, nor of magnetic iron ore, so abundant in the gold alluvia. The platinum had formerly, it appears, been found, for the most part, in fragments from the weight of a zolotnik to near one pound, though rarer examples had occurred of pieces weighing from three to upwards of eight pounds. According to Rose, the major part of the detritus associated with the platinum consists of serpentine, with very rare appearances of hypersthene or other materials, the ground over which it has been washed being either chlorite schist or quartzose talc schist, the latter containing diffused epidote. The platiniferous alluvia on the west slope of the Ural ridge, like the gold alluvia on the east, have in truth been drifted into adjacent depressions from the culminating peaks of hornblende slate, serpentine, and greenstone, and are occasionally from 10 to 12 feet thick.”—*The Geology of Russia in Europe, by Roderick Impey Murchison.*

For the applications of platinum, see p. 76.

## TELLURIUM.

Case 23.—The few minerals which contain tellurium occur, in limited quantities, with the gold and antimony ores of Transylvania.

The native metal is now exceedingly rare, but half a century since it was found in rather large quantities in Transylvania, and was melted to extract the small quantity of gold which it contains.

In 1782 Müller and Reichenstein showed that the ores of tellurium contained a peculiar metal; Klaproth confirmed this. Sir H. Davy examined some of the oxides, but to Berzelius we are especially indebted for our knowledge of this metal.

## MERCURY.

Case 23.—This metal is occasionally found native in small globules on cinnabar or in the fissures of the gangue, but the native metal usually contains a small proportion of silver, the amount of which sometimes rises to a considerable extent, forming the species called *Amalgam*. Most of the quicksilver of commerce is, however, obtained from the sulphide known as *Cinnabar* or *native vermillion*. In Europe the most important mines are those of Idria, in Carniola; and Almaden, near Cordova, in Spain; whilst in California valuable deposits of this ore occur at New Almaden. The metallurgical treatment of cinnabar will be noticed at p. 118.

## ARSENIC.

Case 23.—The collection of foreign ores is brought to a close by a few arsenical minerals. Of these the principal are the bright aurora-red bisulphide of arsenic called *Realgar*, and the lemon-yellow tersulphide known as *Orpiment*, of which the former is the

more important. With these is placed a cup beautifully carved in native realgar by the Chinese, who highly esteem the mineral for its powerful medicinal properties. It has been found necessary to protect this specimen from the action of light and air, since the solid red mineral after long exposure disintegrates to a yellow powder. Both the arsenical sulphides have long been employed as pigments, but for this purpose they are usually prepared artificially.

## SPECIMENS TO ILLUSTRATE THE PHENOMENA OF LODES OR MINERAL VEINS.

### Wall-cases 24 to 36.

The cases occupying the circular or north end of this floor are devoted to the exhibition of an instructive series of specimens intended to illustrate, within such a space as might be conveniently studied, many of the conditions under which *lodes* or mineral veins occur, and the general characters which they present. For the purpose of aiding those who may not be familiar with the phenomena of mineral formations, the following popular description of the more important circumstances connected with these accumulations is written; a more detailed notice will be found in the remarks of Mr. Smyth in the Mineral Catalogue (p. 88 *et seq.*)

It may, indeed it does, appear to many who are familiar with our mineral districts that the utmost uncertainty prevails in everything associated with the processes of mining. "Where it is, there it is," is a bye-word among many practical miners, who mean thereby to express their ignorance of any general laws by which we may be guided in search of metalliferous treasures. Admitting that our knowledge is insufficient to enable any one to determine whether there exist metallic ores at a considerable depth beneath our feet, in the earth's crust, by mere observation of the surface, and that, consequently, mining explorations must be to a great degree speculative, it is yet certain that those mineral formations are distributed in obedience to some exact laws, and that, like all natural laws, the discovery of them is within the reach of the human mind. Observation, experiment, and thought will, no doubt, sooner or later advance man to a knowledge of the conditions upon which the accumulation of metalliferous minerals depends. In the meantime it is important, by the study of such collections as these, that every student should familiarize himself with the physical phenomena exhibited by the deposits within mineral lodes, and learn the conditions which prevail in any of those districts where subterranean explorations are carried on.

*Model of a portion of a Mining District in Cornwall. Central Series. No. 24.*—By reference to this model, near Wall-case 25, the character of mineral lodes will be understood. The two dissimilar woods are intended to illustrate the prevailing rocks—granite and *killas* or clay slate—of that important mining county, Cornwall. The lines which run across these rocks are supposed to represent mineral lodes, containing either tin or copper, as shown by the different colours introduced. Any one imagining this model to represent some square miles of country, across which there has occurred extensive cracks, either in the process of the consolidation of the rocks, or by mechanical force since the period of consolidation, will realize the facts, in the main, of our mineral-lode formations. Cracks have been formed, no matter how, in the rocks they traverse, and these fissures have

been channels through which water passed to considerable depths into the crust of the earth. In the process of time those fissures were filled with earthy or metallic minerals, and probably under the influence of the immeasurable force of the crystallization of such masses, not only were the first fissures enlarged, but lateral ones formed, which would eventually partake of the general character of the main fissure or lode. By the study of the *model of the lead mine at Nentsberry Greens, Alston Moor*, No. 27, opposite Case 20, in the county of Cumberland, it will be seen that even in a stratified country the mineral lodes may, in like manner, be regarded as cracks extending from the surface to an unknown depth through the different strata.

The common hypothesis formerly adopted was, that the veins were filled with matter introduced from below, which either was injected in a state of igneous fusion, or ascended by sublimation; but this view is generally abandoned, very few of the facts observed appearing in any way to support it.

By some experimentalists, who have succeeded in producing artificially, by the agency of electricity, miniature mineral lodes, those valuable natural formations have been referred to electrical power. We must not, however, too hastily decide upon this,—the probability being that a set of physical forces, which are as yet only dimly seen by the eye of science, acting on the material particles will be found to be the causes regulating the effects under consideration.

It is certain that in Devon and Cornwall there are distinct indications of the influences exerted by two dissimilar rocks in producing the formation of the metalliferous minerals. It is evident too, that a main line of direction is observed by mineral lodes, and usually the direction of lodes containing the ores of lead is nearly at right angles to that of the copper and tin veins in the same district; the latter coursing nearly east and west, whilst the "cross courses" and lead veins run almost north and south. This is well seen in the *model of Holmbush Mine*, No. 30. Again, in the lead districts of Wales and of the North of England, we find the ores of this metal commonly occurring in the limestone bands, and appearing only slightly, if at all, in the sandstone and shales associated with the limestone. There are, however, districts, and extensive ones, in which the lead occurs in the sandstone and not in the limestone, and there are some in which the preference appears to have been given to the shales. This is strikingly shown at the Grassington and at the Cononley mines. Such facts prove to us that some conditions beyond those which are dependent upon the chemical constitution of the rocks are to be sought. Indeed, the whole subject is open for investigation, and a rich harvest awaits the student of nature who may zealously and thoughtfully cultivate this extensive and important line of research.

Prepared by these general preliminary remarks to understand the aim of the collection, we may at once proceed to its systematic examination. The series commences in Case 24 with a number of specimens illustrating the formation of veins on a small scale in nodular concretions of clay-ironstone, by the contraction which the nodules have suffered during consolidation, and the subsequent deposition of various minerals in these fissures of contraction. Not only do carbonate of lime, quartz, hatchettine, and other non-metallic minerals occur in such cracks, but associated with these are found various metalliferous minerals identical with those which form the object of exploration in metallic veins; such, for

instance, as zinc blende, galena, and copper pyrites. The remainder of this case is occupied by samples of narrow simple veins known from their small breadth as "strings" or "threads." Some of these branches consist of metallic mineral, others of non-metallic; and some interesting specimens are introduced to show the differences observable in the character of a vein in passing from one rock to another.

The series of simple veins is continued in the succeeding Cases (Nos. 25 and 26), the veins, however, increasing in width or becoming more powerful. In many specimens introduced into this part of the series it will be observed that the minerals instead of being gathered into strings are distributed through the rocks themselves in an irregular manner; this is especially the case with tin-stone, which frequently occurs disseminated through granitic rocks. It has been suggested that in many cases the metalliferous mineral has been segregated or separated from the surrounding rocks, and accumulated in the form of veins, the particles of a like character being drawn into these lines of accumulation by some of those mysterious molecular forces which are but little understood.

From the simple veins which, with few exceptions, have consisted of a single mineral only, we pass in the next two Cases (27 and 28) to illustrations of lodes, consisting, first of two minerals, and then of several. These instructive examples are of high practical value, as illustrating the subject of the "paragenesis" of minerals, or the characteristic association of certain species,—a question of the deepest interest alike to the mineralogist, the geologist, and the miner.

In some instances the formation of the different minerals has evidently been contemporaneous, as in the fine example from the Ecton mines (No. 194), in which calc-spar and copper pyrites have simultaneously crystallized; but in other cases the minerals have obviously been formed in succession, as seen in the fine Brazilian veinstone (No. 203a), where we observe a sequence of quartz, dolomite, and magnetic pyrites. The association, however, is in these cases, to a certain extent, irregular, and it remains for us to study in Case 29 those specimens in which may be traced a definite succession of regular deposits. This is strikingly illustrated by the beautiful specimens of "riband" or "banded" veinstone from Saxony (Nos. 232 and 233), in which we notice, within a very limited width, a succession of alternate deposits of quartz, galena, heavy-spar, iron pyrites, and zinc blende, the layers being repeated with tolerable symmetry on each side of the veinstone. Among the instructive specimens in this case may be noticed the fine Bohemian veinstone (No. 252), which conveys an excellent idea of the general characters of a lode; but it is to be regretted that space does not admit of its being placed in its natural position.

Some interesting specimens in the following Case (30) exhibit certain peculiarities in the succession of the deposits. In many of the examples crystals of a later-formed mineral have been deposited on particular sides only of the pre-existing mineral, the cause determining this elective action being in many cases far from obvious.

Vein-deposits after their formation have often been subjected to the action of certain dislocating forces, which have again established fractures, and in these new fissures other minerals have been deposited, thus producing the structure called "comby." Several examples of comby lodes are introduced, in which the succession of plates shows that the opening must have been several times repeated at distinct intervals.

The mineral deposited in a lode occasionally serves to cement together angular fragments of the neighbouring rocks, and even of other veins. In Case 31 is a large collection of such "brecciated" lodes, in which a *non-metallic* mineral has acted as the cement; fragments of sandstone, for instance being cemented by heavy-spar; whilst Case 32 is devoted to the exhibition of those in which a *metaliferous* mineral has been introduced as cement, as when sandstone fragments are bound together by galena. In the upper part of Case 33 are some interesting breccias containing fragments of pre-existing lodes; pieces of copper pyrites, for instance, being embedded with fragments of quartz in a "flucan" or clay.

The fine pendent forms of the stalactites, introduced in Case 33, will naturally attract attention, and it will be observed that many of the Cornish specimens exhibit a regular sequence of deposits, the stalactite having been coated by a succession of newer-deposited minerals.

The polished and striated surfaces of the "slickensides," in Case 34, evidently point to some sliding or grinding motion in the mass constituting the lode, affording evidence of movement since the formation of the metalliferous matter, such movement as would be sufficient to account for the fissures and breccias to which allusion has been made.

From these evidences of mechanical disturbance in mineral lodes, we may pass to those changes of a chemical character which vein-deposits frequently suffer, as especially attested by the phenomena of *pseudomorphism*. In this case is arranged a large collection of the so-called "displacement" pseudomorphs, or those in which one mineral is deposited either upon or in the place of another. Of such changes the curious "boxes" from Virtuous Lady Mine, near Tavistock, are interesting examples: a coating of carbonate of iron has been deposited upon cubic crystals, probably of fluor-spar, and by the subsequent removal of these crystals the encrusting carbonate has been left in the form of large hollow cubes, in which quartz and copper pyrites have finally crystallized. It may thus be readily understood how a cellular character may be imparted to a lode by the hollows formed on the removal of the original minerals.

The formation of certain pseudomorphs by the very gradual substitution of one mineral for another has been explained in connexion with the interesting crystals of tin-stone in the form of felspar (p. 82).

In addition to the displacement and substitution-pseudomorphs just noticed, there is yet a third group in which the change of mineral is readily explicable by chemical action, and of these "alteration"-pseudomorphs a series is exhibited in the succeeding Case (35). These may result either from the addition or from the removal of a constituent, or from a partial exchange of ingredients. Thus the crystal of calamine in the form of a large scalenohedron of calcite has been formed by the exchange of lime for oxide of zinc. So obvious in many cases is the formation of these "epigenic" pseudomorphs that it may, to a certain extent, be successfully imitated, and an interesting series of such artificial pseudomorphs, prepared by Mr. H. C. Sorby, F.R.S., is placed in this case. In nature, such chemical action occurs in many cases on a very extended scale, affecting mineral masses often of enormous extent. To illustrate these changes there is introduced into this case a large series of minerals occurring mostly in the upper parts of lodes, where the *original deposits* have been subjected to atmospheric influences. Thus the crystals of anglesite often found in the shallow workings

of a lead vein are true products of alteration, having resulted from the absorption of oxygen by the galena forming the body of the lode, and the consequent oxidation of the sulphide of lead to a sulphate. A very common alteration in mineral veins is illustrated by No. 538, in which large pentagonal dodecahedrons of iron pyrites are superficially converted into brown iron ore, by the elimination of sulphur and the addition of oxygen and water. On the "back" or outcrop of a lode such a change is exceedingly common, the superficial deposit of loose brown iron ore, which thus acts as a cap to the ore beneath, passing under the name of "*gossan*." The greater part of the following Case (36) is devoted to the display of varied samples of this gossan, which, although not perhaps very attractive to the eye, are nevertheless of the highest importance to the miner, who is frequently enabled to judge from them of the probability of cutting ore in the deeper workings.

The remaining portion of this Case (36) is occupied by a collection of specimens illustrating a class of chemical changes, of a different character from those already studied. In these specimens the decomposition of certain metallic minerals has resulted in the production of native metals: thus there will be found among the specimens, crystals having the characteristic octahedral form of red oxide of copper, but consisting entirely of the native metal; the copper having been reduced from its combination with oxygen; and it is indeed probable that many of the metals which now occur in a native state have been reduced by successive stages from various combinations, often of considerable complexity.

## COLONIAL PRODUCTIONS.

Wall-cases 37 to 42 on E. side.

### AUSTRALIA.

Case 37.—The gold fields of Victoria, which naturally claim priority in any notice of the mineral products of Australia, are represented by a number of specimens which from their interest are separated from the general collection, and grouped together in a special case on the western side of the room, which has been noticed in the description of the central series (*see* p. 69). Second only in interest to these gold fields are the remarkable copper deposits in the neighbouring colony of South Australia, well illustrated by the specimens in the case before us. These are principally from the famous mines of Burra Burra, situated about 90 miles N.E. of Adelaide. The rich deposits of carbonate of copper in the earlier workings at these mines resemble in many respects the malachite formations of Russia, already described. In a great basin, formed in an amphitheatre of hills, is an immense deposit of clay, resulting from the decomposition of the clay slate of which the surrounding hills are formed. In this clay the remarkable deposit of copper ore is found. There are some evidences which appear to show that the earliest condition of the mass was that of oxide and native copper; this, from the continued action of carbonic acid, contained in all probability in the water, was converted into a carbonate. There are no appearances of any mineral lode of the character which occurs in our own copper mines. The veins, said to be met with, are merely extensions of the mass by infiltration through the clay.

The Burra Burra mines were started on the 5th September 1845. In spite of the rudeness of the early workings, their distance from

the shipping port, and the disadvantage of unmade roads, these remarkable mines nevertheless yielded during the first five years a profit of nearly half a million sterling; certainly one of the most successful mining adventures upon record. When, in 1851, the gold fever set in, these important mines were deserted by the working miners; but when men had begun to discover that the profits which are obtained from the exciting but uncertain search for gold are not commensurate with the risks run and the labour expended, they returned to more stable sources of employment, and in the early part of 1855 the workings at Burra Burra were resumed. For several years little was heard of the mine, and its fame was eclipsed by the fine discoveries in Yorke peninsula; but recently the mines have again been brought into active operation.

In Case 36 (p. 69), on the western side of this floor, are some fine specimens of the red oxide and blue and green carbonates from the same mines; and in the lower hall is another large mass of the ore (No. 34). There will also be found in the hall a fine sample of the ore (No. 174) from the workings of the Great Northern Mining Company of South Australia, commenced in June 1860, in the district north of Port Augusta, at the head of Spencer's Gulf (p. 48).

Case 38.—The South Australian copper ores are continued in the upper part of this case. Samples of copper glance and other rich ores are exhibited from the Kapunda mines, which have been successfully worked since 1844, and were indeed the first workings in the colony. Other specimens have been contributed by the mines of Mount Barker, Reedy Creek, Kanmantoo, and New Cornwall, the last-named being situated in the neighbourhood of the brilliantly-successful workings at Wallaroo, on Yorke peninsula.

The discovery of copper-ore in this district was made by a shepherd in 1860, and the Wallaroo mines were at once started. Another discovery was soon afterwards made about 10 miles south of Wallaroo, which resulted in the formation of the valuable Moonta mines.

Passing over the lead, iron, and antimony ores, which are at present only of inferior importance to the colony, we meet with a number of samples of tin ore.

The Australian *black sand*, as it was commonly called, did not for some time attract attention, except for the gold which it contained. Eventually, however, it was found to contain tin; some samples were sent to England and determined to be of considerable value. The quantity of tin produced in Victoria, up to the end of 1873, has amounted to upwards of 4,000 tons.

Vast discoveries of tin-stone have recently been made in New South Wales and in Queensland, where not only do valuable lodes occur in granitic rocks, but stream-tin is found abundantly in the beds of many of the rivers and in alluvial flats. Tin-ore has also been recently discovered at Mount Bischoff in Tasmania. The new Australian and Tasmanian deposits are fairly represented in the case before us. In 1874 we imported 5,800 tons of tin from the Australian colonies.

The few specimens of Australian coal will be regarded with much interest, for the carboniferous formations of Australia have yet to be developed. Important deposits are, however, worked in New South Wales and in Queensland.

#### NEW ZEALAND.

Case 37.—Of the few minerals exhibited from the Northern Island, perhaps the most interesting is the fine *magnetic iron sand*, which occurs in deposits of vast extent along the shore of New Plymouth,

at the base of the trachytic cone of Mount Egmont, in Taranaki. The excellent quality of the steel prepared from this sand is supposed to be referable to the large proportion of titanium present, an analysis of the ore yielding 88·45 per cent. of oxide of iron, and 11·43 of oxide of titanium.

The samples of auriferous quartz sufficiently show the character of the gold ore yielded by the famous Thames gold fields, near Auckland.

There will also be found in this case a specimen of copper ore from the lower palæozoic rocks of Kawau, near Auckland; and some samples of New Zealand tertiary coal obtained from Waikato, distant from Auckland 35 miles, and 10 miles from Manukau harbour. Coal is also obtained at Matakana, 15 miles north of Auckland.

#### EAST INDIES.

Case 37.—An interesting and extensive series illustrating the varieties of corundum stands at the head of the Indian minerals. The name *corundum* is applied to the opaque, roughly crystallized varieties of native alumina, whilst the massive and more impure forms of the same species are known as *emery*; the passage of corundum into emery is illustrated in this series. From its hardness, which is inferior only to that of the diamond, the mineral in its coarser forms is extensively used for grinding and polishing purposes (p. 42). As these varieties of alumina will again be brought under notice in describing the contents of the horse-shoe case, we may pass, without further remarks, from this series to the *iron ores* of India, which will naturally attract much attention. The lower part of this case is devoted to metallurgical illustrations, but the ores from which the metal is reduced are principally shown in the following case.

Case 38.—The celebrated "*wootz*," or *Indian steel*, is manufactured by the natives, chiefly from the magnetic ores, of which many samples are here exhibited. The method employed for smelting this ore is very rude. Layers of small pieces are disposed alternately with others of charcoal in an open furnace, and exposed to the blast of two small bellows made of goat-skins. The metal when reduced falls into a hole at the bottom of the furnace in the state of malleable iron. To convert this into wootz steel, a small wedge is cut from the iron cake, and placed with pieces of dry wood in a clay crucible, which is heated in a rude furnace until the iron becomes carbonized, and on breaking open the crucible the steel is found at the bottom in the form of the small conical cakes here exhibited.

The iron manufacture has been carried on somewhat extensively in the Damoodah valley and Beerbhoom. "At Dyoucha," says Professor Oldham, "there are at present about 30 furnaces at work for the reduction of the ore into pig iron, or what is here called *cuteha* iron, and about as many more for refining it, or making it *pucka*; the two operations being carried on by totally different sets of people, and, what is curious, by people of different religions, those who reduce the ore in the first instance being invariably Mussulmans, and the refiners as invariably Hindoos.

"From each of these furnaces when at work between 20 and 25 maunds of pig iron will be turned out during a week. The furnaces work throughout the year, with only occasional stoppages for poojahs; that is, provided the proprietor has been able to lay in a stock of ore and charcoal previously to the rains commencing, sufficient to last till the weather again admits of the miners obtaining the ore

From each furnace, therefore, a produce of pig iron of about 1,100 maunds, or nearly 35 tons, is annually obtained."

At Dyoucha are 30 furnaces, at Narainpore about the same number, at Damrah four, and at Goanpore six, or in all about 70 furnaces, producing nearly 2,380 tons of pig iron every year. In refining nearly one fourth of its weight is lost, 10 *maunds* of the *cutch* iron yielding about 7 *maunds* 10 *seers* of the *pucka* iron. This will give the entire produce of the whole district at about 1,700 tons of refined iron.—*Oldham's Report on the Damoodah Valley*, 1852.

A few samples of copper and antimony ores are introduced. It is known that the Himalayan mountains contain copper and lead, but the mines have only been worked superficially, and it is doubtful whether they would repay the great cost which must be incurred. In several other districts, Ulwar and Beerbhoom, Bellary, Dhuniara, Tennasserim, and Nepal, copper ores are found.

A rather extensive series of useful non-metallic minerals is exhibited from the Madras Presidency. These embrace several varieties of *kaolin* or china-clay, valuable in pottery manufacture (p. 141); and a collection of variously-coloured *ochres*, which, both in a native and a burnt state, are available as pigments.

Case 40.—The non-metallic minerals of India are continued in this case, the upper shelves being occupied by some fine specimens of zeolitic minerals from the tunnels cut through the trap-rocks of the Bhoire Ghaut during the construction of the great incline which ascends the Syadrahee range on the line between Bombay and Poonah.

Among the minerals on the following shelf, the specimen of *kunkur* is notable as a representative of the vast deposits of this siliceous variety of carbonate of lime, which occurs in singular concretionary forms, and is largely burnt in India for lime.

The specimens of tin ore from the Malayan peninsula, and from the isle of Banca to the south of it, are interesting from their commercial importance. From these, and other adjacent localities, tin has long been obtained, and Humboldt was of opinion that the Phœnicians, by means of their factories in the Persian Gulf, maintained a trade in tin with India; and as the word *Kassiteros* is the ancient Sanscrit word *Kastira*, he is disposed to regard the islands of the Eastern Archipelago as one set of islands, to which the term *Cassiterides*, or "land of tin," was applied.

Tin from our other eastern possessions comes to us through Singapore; but this is mixed up with much which is produced in the Dutch East Indian possessions. In 1874 we received from the Straits Settlements 4,177 tons of tin.

#### BRITISH AMERICA.

Case 40.—The mineral wealth of Canada, with which the labours of the Geological Survey have made us acquainted, is very fairly represented through the courtesy of the late Sir William Logan. Although some of the specimens, on account of their size, are necessarily placed in the following cases, it will be convenient to describe in this place the whole of the Canadian series.

As especially interesting among the non-metallic minerals may be noticed the *apatite* or phosphate of lime, which occurs in considerable deposits in the Laurentian limestones, and is highly valued by the agriculturist as a useful fertilizer (p. 48). The plates of Canadian *mica*, which are found of extraordinary size and thickness, have been employed in certain situations as a substitute for the more

easily injured glass (p. 68); and the *graphite*, or black-lead, has also been worked, although occurring only in irregular deposits of no very considerable extent (p. 123).

Whilst the limestones are notable for furnishing these minerals, the granitic and gneissose rocks deserve mention for the fine specimens of felspar which they yield. The peculiar soda-felspar called *peristerite* is remarkable for its beautiful bluish opalescence, whilst the variety of potash-felspar known as *perthite* is attractive by its peculiar banded structure and aventurine-like reflections. See polished specimen in Horse-shoe case (p. 132).

A sample of coralline limestone from Enniskillen is interesting as the rock from which probably arises the Canadian *petroleum*, or rock-oil; the wells in this locality being carried through a considerable thickness of palæozoic shales overlying this corniferous limestone.

Passing to the metallic minerals, we may notice from the Bruce mines, on the shores of Lake Huron, the fine samples of the *copper ore*, which occurs in rich veins traversing the Huronian rocks, or those which immediately overlie the Laurentian series. Considerable interest attaches to the Canadian iron ores, the *bog ore* having a very wide superficial distribution, and the richer *magnetic ore* occurring in beds of prodigious extent. The *titiferous iron*, from its occurrence in large quantity, promises to become of considerable importance, whilst certain varieties of *iron pyrites* appear to contain an amount of cobalt sufficient to render profitable the extraction of this somewhat rare metal. From Eastern Canada are obtained the *chrome iron ores*, which, as usual, are associated with serpentine rocks. For further information on this series the visitor should consult the "*Reports of the Geological Survey of Canada.*"

Before leaving Case 40 attention should be drawn to the specimens of gold, and models of nuggets, from the Gilbert River in Lower Canada.

Case 41.—The specimens in this case which will doubtless be regarded with most interest are those illustrating the gold discoveries which have been made in British America during the last twenty years. From Nova Scotia are exhibited samples of the so-called "*barrel-quartz*" of Laidlaw. Occurring beneath only a few feet of quartzose rock, it forms an extensive horizontal bed, presenting a remarkable succession of folds or contortions; probably the result of lateral compression. The undulating surface of the deposit, which has suggested the local name, is well seen in the water-colour sketch in the upper part of the case, where the barrel-quartz is exposed by removal of the superficial rock.

A prominent position in the case before us is necessarily given to the collection illustrating the extensive gold districts of British Columbia. It appears that as early as 1852 small quantities of gold were found in Queen Charlotte Island, and the metal was afterwards discovered on the mainland, in the Frazer River valley, and in various parts of the Cascade range. The first official report of these discoveries, which was received in 1856 from the Governor of Vancouver Island, failed to excite any considerable attention; but the extent of the deposits and the success of the operations which were in progress being confirmed by subsequent reports, public attention was at length aroused, and in 1858 vast numbers of emigrants flocked to the new colony.

The great centre of the most successful workings was the rich auriferous district situated some distance inland, and known (from being a favourite haunt of the reindeer or *caribou*) as the Cariboo

country. The beds of the Frazer River and its numerous tributaries were also highly productive, and the alluvial terraces which border many of the streams yielded much gold to the "bench diggers." More to the south, on the eastern side of the Cascade range, gold has been worked in the Similkameen, the Okanagan, and other streams which are direct or indirect tributaries to the Columbia River.

After a period of successful operations, in some cases of the most brilliant character, the workings gradually became less productive, and were for the most part abandoned; the washings at present being carried on only to a very limited extent, principally by Chinamen.

The *West Indies* are represented by a small number of specimens, chiefly from Jamaica. The existence of copper ores and other minerals in this island have long been known, but the explorations which have hitherto been made have not been sufficiently extensive to decide whether the metalliferous mineral exists in sufficient quantities to warrant a large outlay of capital.

#### SOUTH AFRICA.

Case 42.—If the copper ores just noticed are only of meagre interest, it is far otherwise with those in the collection before us. The copper ores of Namaqualand, which merit considerable attention, are very fairly represented by a tolerably numerous series, contributed by Mr. Wyley. The ores occur in veins traversing highly contorted granitic and gneissose rocks, and presenting a considerable variety of copper-bearing minerals. In the upper part of the deposits, where surface-action has been most active, the copper ore is chiefly in the form of silicate and oxide, but these are commonly followed at a greater depth by purple ore, and this again by copper pyrites. Considerable quantities of iron ore occur with these copper minerals, and a little molybdenite is occasionally present.

The diamond fields of South Africa are illustrated by specimens in the central horse-shoe case (p. 122). Among the non-metallic minerals in the case before us there are several specimens of the brown fibrous quartz which under the name of *cat's-eye* has lately been polished and largely used for purposes of ornament.

In the upper part of the case are some *Indian spears from South Africa*, made from the native carbonate of iron, reduced by cow dung.

Having completed our survey of the Colonial products, we return to the British ores which remain to be noticed. These are the lead and iron minerals which occupy the succeeding cases.

#### BRITISH ORES.

##### 2nd Division.

##### EASTERN SIDE. Wall-cases 43 to 56.

##### LEAD.

Cases 43, 44, 45.—Lead mining has been carried on in this country from a very early period. When in the possession of the Romans, many of the lead mines in Wales and England were worked, and considerable quantities of lead obtained, as we may infer from the immense accumulation of slags in Derbyshire, the Mendip hills,

and elsewhere. There does not appear to have been any period in our history during which mining for lead was not followed to some extent; but in the reigns of Henry VIII. and of Queen Elizabeth, especially in the latter reign, a fresh impetus was given to British mining by the introduction of a number of German miners. That mining for lead must, previously to this, have been extensively carried out is proved by the circumstance that Edward the Black Prince took several hundreds of the Derbyshire miners into Devonshire, and it is said that the result of his mining speculations in the west was the realization of wealth sufficient to defray the expenses of his French wars. Many curious laws were made for, and special privileges were granted to, particular mining districts, as the King's Field in Derbyshire, and the Myne-deeps—as the Mendips were formerly called. The workings for lead in Cardiganshire by Sir Hugh Myddelton are noticed at p.

*The Dish of Lead.*—Among the curious customs of Derbyshire in the King's Field was this:—The ore was obliged to be measured in the presence of the barmaster before it was removed from the mine, for which purpose, in Wirksworth wapentake, a rectangular box was used, 28 inches long, 6 wide, and 4 deep, and reputed to hold 14 Winchester pints when level full. In measuring the ore every 25th dish is set aside by the barmaster as the King's cope or lot. An old dish of this kind stands on the model of the steel-works No. 21, at the northern end of the room, and bears the following engraved inscription:

This dishe was made the iiiiij day of October the iiii year  
of the Reigne of Kyng Henry the viiii. before George  
Erle of Shrotheshbery steward of ye kyngs most honorable  
household, and also steward of all the honour of Tutbery, by  
the assent and Consent aswelle of all the Mynours as of all

The Brenners Within and Adjourning the lordshipp of  
Wyrkysworth percell of the said Manour. This dishe to  
Remayne in the Hoose hall at Wyrkysworth hangyng  
by a Cheyne So as the Merchantes or mynours may have  
resorte to ye same at all tymes to make the true mesur aft the same.

It appears now usual for the Derbyshire smelters to consider 58 lbs. as the standard weight of a 14 pints dish of ore.

The principal lead-producing counties of England are Durham, Northumberland, Cumberland, Yorkshire, Derbyshire, Shropshire, Devonshire, and Cornwall; in Wales, Cardiganshire, Flintshire, Montgomeryshire, and Denbighshire. Lead is also obtained from four different counties in Scotland, from eight in Ireland, and it is raised in large quantities in the Isle of Man. Ores from nearly all those districts will be found in these cases.

The most important ore of lead is the widely diffused sulphide called *Galena*. In addition to the lead, of which the purer varieties of galena contain upwards of 86 per cent., various other metals are usually present in greater or less quantity. Of these, silver is the most important, and it is indeed highly probable that neither silver nor gold is ever entirely absent from galena. The former is extensively extracted by a process which will be subsequently described (p. 116).

Following the specimens of galena are samples of other lead ores, less widely diffused than the sulphide, but many of them, nevertheless, of considerable importance. Foremost among these stands the carbonate of lead, called *Cerussite* or *white lead ore*. This mineral

sometimes occurs in acicular or needle-shaped crystals, of which a magnificent specimen from Devonshire will be found in the central case No. 33; but more frequently it is found in an earthy form often investing galena, from whose decomposition it results. Among the oxidized lead ores will also be found some brilliant rhombic crystals of *Anglesite* or sulphate of lead, and of the fine blue mineral called *Linarite*, a sulphate of lead coloured by copper. The phosphate of lead termed *Pyromorphite*, and known to our miners as "green linnets," is a mineral in which the phosphoric acid is frequently replaced to a greater or less extent by arsenic acid, thus passing into the species called *Mimetite*. In these minerals the phosphate and arseniate of lead are associated with plumbic chloride.

The rare vanadate of lead already noticed as *Vanadinite* is related by form and composition to the phosphates and arseniates of lead, and these again to the phosphate of lime called apatite.

### IRON.

Case 46.—*Iron pyrites*, although containing nearly one half its weight of metal, is used not so much as a source of iron as of sulphur, and is hence commonly known as "*sulphur ore*." In Cornwall, where it is by no means an uncommon constituent of copper veins, it passes under the name of "*mundic*," whilst the coal miner, who constantly meets with impure varieties, recognises them as "*brasses*."

The name *pyrites* is derived from the Greek *πυρρς* (*pyrites*), because, as Pliny says, "*there was much fire in it*." Heaps of pyrites undergoing decomposition by the action of the atmosphere develop a large quantity of heat, in some instances sufficient to set the mass on fire.

Iron pyrites is essentially a bisulphide of iron, and is therefore identical in chemical composition with *Marcasite*, a mineral which, however, crystallizes in totally distinct forms; ordinary pyrites appearing in cubes, octahedrons, or certain hemihedral forms derived indirectly from the cube, whilst marcasite occurs in a series of prismatic forms, which have suggested the name of *rhombic pyrites*. It frequently appears in irregularly shaped nodules common in the chalk, and the crystals are often aggregated into groups, forming the variety called "*cockscomb pyrites*."

The arsenical pyrites or *Mispickel* has already been noticed as a source of arsenic (p. 91), and the bronze-coloured magnetic pyrites or *Pyrrhotine* has been mentioned in the description of the foreign ores.

*Vivianite*, *childrenite*, and *pharmacosiderite* are minerals which will be found in this case, but all being of rare occurrence they merit no special description.

Case 47.—The value of *Magnetic iron ore* in Sweden, Russia, India, &c., for the production of a very superior quality of steel has already been noticed. In this country, however, the ore is comparatively unimportant, occurring only in very limited quantity. The peculiar pisolitic ore from Rosedale in Yorkshire is interesting from its occurrence in the lias as a deposit of considerable extent.

Case 48.—As the most important of the numerous localities in which the valuable *Hæmatite* or *red iron ore* is found in this country, may be mentioned Ulverstone in North Lancashire, and Whitehaven in West Cumberland. The ore is highly prized for yielding a pig-iron well fitted for conversion into Bessemer steel. The crystallized variety called *specular ore* or *iron glance* is represented by some specimens from the Cleator Moor deposits, where it occurs in cavities

in the compact ore. The delicate scaly or lamellar crystals from Devon and Anglesey show the characters of the foliated variety of specular iron called *micaceous iron ore*; whilst the fine reniform and mammillated samples of compact hæmatite from Cumberland and Lancashire exhibit well the characteristic forms which have suggested for these varieties the popular designation of "*kidney ore*." On account of the red colour of the powder the name *hæmatite*, from *aima* (*haima*) *blood*, is applied to this species.

Case 49.—A mineral so abundant and so widely diffused as *Limonite* or *brown iron ore* naturally requires an extensive series for its illustration. Among the numerous localities represented in the case before us, the Forest of Dean may be cited as a district in which the brown ores have long been raised. The botryoidal and stalactitic forms, sometimes called *brown hæmatite*; the fibrous varieties, termed from their structure *wood iron ore*; and the friable earthy forms known as yellow and brown *ochres*, are so many varieties of this one species. The composition of these varieties is subject to variation within certain limits; but a crystallized hydrous peroxide of iron of definite composition is occasionally met with, and has been separated as a distinct species under the name of *Göthite*. The magnificent specimens of *göthite* from Restormel, near Lostwithiel, in Cornwall, are in every way worthy of notice.

The brown iron ores of the secondary strata, especially those of the lias and the overlying oolites, have acquired considerable importance within the last few years. Samples of these will be found in the lower part of this case. The celebrated *Cleveland ironstone* was discovered in 1848-49, on the north-eastern coast of Yorkshire. "From Redcar to Middlesbro'-on-Tees there crops out a solid stratum of no less than 15 feet thick. This remarkable ironstone seam extends over a region of some hundreds of square miles. It is capped by sandy shales, containing scattered nodules of ironstone, and ultimately, above the *marlstone series* to which it belongs, by the upper lias shale, so well known along the Whitby coast for its fossils, jet, and the application of some of the beds to the manufacture of alum."—(*W. W. Smyth*.) The main body of the *Cleveland ore* is a carbonate of the protoxide of iron, but the upper part of the deposit passes into brown ore.

In Northamptonshire and Lincolnshire, ironstones are now extensively worked and smelted. The *Northamptonshire ironstone* occurs at the base of the Inferior Oolite; while the *Lincolnshire ironstone* is found partly in the Lower Lias and partly in the Neocomian series. A lias ironstone is also worked at Fawler in Oxfordshire, and an oolitic ore (coral rag) at Westbury in Wiltshire (p. 60), whilst Buckinghamshire yields iron-ore in the Lower Greensand.

Case 50, &c.—The characters of the pure carbonate of iron have been noticed in the description of the foreign ores (p. 91). In the case before us, in addition to the rhombohedral and lenticular crystals from Cornwall, are specimens of spathose ore from the valuable deposits of the Brendon Hills in Somersetshire, and of Weardale in Durham (p. 60).

Spathose iron ore is a mineral whose composition is subject to considerable variation, the carbonates of lime, magnesia, and protoxide of manganese frequently replacing to a greater or less extent the carbonate of iron. Moreover this carbonate of iron is frequently associated with impurities which interfere with its crystallization, and give rise to the dark-coloured massive varieties called *clay-ironstones*. These impure carbonates—which are so profusely distributed throughout our coal-measures, partly as regular seams of variable thickness, and partly as nodular concretions—constitute

the ore which, in this country, yielded until recently by far the largest amount of our iron—a fact by itself a sufficient apology for the rather large amount of space devoted to the display of these ores, confessedly somewhat unattractive in appearance. But the exhibition of a complete series is the more desirable in an institution of a practical character, since the ores, possessing neither crystalline form nor definite chemical composition, are not entitled to take rank as true mineralogical species, and would therefore find no place in a purely scientific collection.

The extensive series of clay ironstones commences with a number of specimens illustrating the characters of the nodular forms, and the minerals which these nodules frequently contain. The lower part of the present case and the whole of the six following cases are occupied by the systematic collection of ironstones, arranged geographically in the following order:—South Wales, North Wales, Shropshire, South Staffordshire, Warwickshire, North Staffordshire, Yorkshire, Derbyshire, and the Northern Counties.

Intercalated with these argillaceous carbonates of iron are a few samples of the carbonaceous ironstone, well known as *black band*. From this ore, which was discovered in 1801 by Mr. Mushet, and is hence frequently called *Mushet stone*, the largest quantity of the Scotch iron has been for many years made.

Information on the series of ironstones will be found in the "Mineral Catalogue," and further details in the Memoirs of the Geological Survey on the "Iron Ores of Great Britain;" whilst the best idea of the value of our iron manufacture will be gained by consulting the "Mineral Statistics."

### THE METALLURGICAL COLLECTIONS.

In the recesses on each side of the room at the southern or Jermyn Street end the visitor will find six flat cases which are devoted exclusively to the illustration of metallurgical operations. These cases are placed, as far as convenient, in front of the wall-cases containing the corresponding ores whose metallurgical treatment is here illustrated; the series of iron-smelting products, for example, being arranged immediately in front of the British iron ores. The processes illustrated in these cases, although for the most part British, are by no means exclusively so; specimens from foreign works being, in many instances, placed by the side of our own productions for purposes of comparison and illustration.

Metallurgical operations, presenting, as they frequently do, considerable complexity in their details, could not possibly be described in a popular guide with anything like scientific precision; but in order that the collection may not be entirely barren of interest to the general visitor, it seems desirable to introduce a brief sketch of the main features of each process, referring for detailed information to any modern work on the subject, especially to Dr. Percy's "*Metallurgy*," or to Phillips' "*Elements of Metallurgy*."

#### COPPER SMELTING.

*Table-case 47.*—The ore when raised from the mine may be more or less pure; it may be mixed with other metallic minerals or with earthy ones, and it has therefore, as a first operation, to be freed as much as possible from those. The processes employed are termed "*dressing*." Of the ores sold in Cornwall in 1874, the highest percentage for copper was 20½, the lowest being 4½. This must not be

understood as the copper contained in select specimens, but as the per-centage of the mass of ore sold. In the boxes in this case are shown the ores in their various stages of preparation until they pass into the hands of the smelter.

Copper smelting, which is conducted in this country almost exclusively at Swansea, in South Wales, involves a somewhat elaborate series of operations, of which a very bare outline must suffice. The dressed ore having been calcined in a reverberatory furnace is fused to the condition of *coarse metal*, which, after calcination, is melted with certain oxidized copper ores, and the *white metal* resulting from this fusion yields, on roasting, a crude variety of copper, which is subsequently refined by exposure to oxidizing influences in a reverberatory furnace. During these operations the sulphide of iron in the ore is converted into an oxide, which, combining with the siliceous matters present, forms a fusible *slag*; and the iron being thus removed, the sulphide of copper suffers decomposition, its sulphur being evolved as sulphurous acid, whilst the oxide of copper, formed during refining, is reduced in the final operation of *toughening*. In this process the surface of the metal is well covered with anthracite, and a *pole*, usually of green birch, is held in the liquid metal, the evolution of gaseous matter causing considerable ebullition. This operation of *poling* is continued until, by the assays which the refiner from time to time takes, the metal is shown to be in the best condition. This operation requires great care; both *under poling* and *over poling* being found injurious.

The various stages in the Welsh process of copper smelting are illustrated by a fine series of specimens presented by Mr. Vivian.

Copper passes into the market in the conditions of *cake* (ingot) and *sheet* copper of various descriptions. That used for making brass is granulated, that its surface may be increased, so as to combine more readily with zinc or calamine. The granulation is effected by pouring the metal in a molten state into a vessel pierced full of holes, supported over a cistern of water. When it falls into hot water the copper assumes a rounded form, and is called *bean shot*, and when into cold water, from its assuming a ragged appearance, it is called *feathered shot*. Copper is also cast, chiefly for exportation to the East Indies, in pieces of the length of six inches, and weighing about eight ounces each; these are called *Japan copper*. By the side of these will be found an ingot of real Japan copper brought from Shanghai. (See also Case 44, p. 75.)

Some specimens in this case illustrate Mr. Weston's process of refining copper by addition of "phosphorus-copper," or a compound of copper and phosphorus. The process has been carried out at the Chatham Dockyard.

*Table-case 48.*—In this case are exhibited some interesting specimens illustrating certain Continental processes of copper smelting.

The treatment of the remarkable *Kupferschiefer* or copper-slate (p. 89) is here illustrated. This schist, which is extensively smelted in the neighbourhood of Mansfeld, contains on an average not more than three or four per cent. of copper, with a small proportion of silver. After calcination for a considerable time in large heaps, the ore is mixed with a certain amount of slag and flux in the form of fluor-spar, and the mixture fused in a cupola furnace; the product being subjected to successive roastings, until at length a concentrated regulus is obtained from which the silver is extracted, and the copper-bearing residuum subsequently smelted. At the time this series was obtained the silver was extracted by *Angustin's method*, which is accordingly here illustrated, but at

present a somewhat different process is adopted. The crude copper is refined in a reverberatory furnace, the refined metal being run out into two external basins, where a little water is thrown on its surface, in order to determine the solidification of the superficial crust, which is removed in the form of a thin circular plate or *rosette*; more water is now thrown on the fused mass, and other discs are successively obtained, until the whole of the charge has been removed. By the side of these German specimens is a small group illustrating the process of copper smelting at Falun, in Dalecarlia, and in the lower part of wall-case 17 will be found a fine sample of the celebrated, but by no means rich, ore of this district.

#### TIN SMELTING.

*Table-case 48.*—In this case will be found an old block of tin obtained from the tin district of St. Agnes, and in the adjacent Wall-case, No. 10, are some other ancient blocks of Cornish tin. Such blocks are called *Jews' tin*, and the rude furnaces, which are not unfrequently discovered in connexion with them, are known as *Jews' houses*. This arises from the fact that during the reign of John, and subsequently, the tin mines of Cornwall were farmed by the Jews. Those blocks, and the furnaces named, are, however, probably much older than this; they possibly belonged to the times when the Phœnician merchants traded with Britain for metals. A model of a remarkable block of tin, which was fished up from off St. Mawes, at the mouth of Falmouth harbour, will also be found in Case 10. The original block is in the Museum of the Royal Institution of Cornwall, at Truro. Sir Henry James has shown, with much ingenuity, that the form of this block was peculiarly adapted for its transport, both by land and water.

Tin smelting is a simple operation, conducted either in the reverberatory furnace or in the blast furnace. The houses in which the first plan is adopted are called *smelting houses*; those in which the latter process is employed, *blowing houses*. The tin ore, having been roasted and washed, is mixed with powdered anthracite; and a small quantity of either slaked lime or fluor-spar, which serves as a flux for its siliceous impurities, is mixed with it previously to its being placed in the furnace and smelted.

During more than six centuries the tin paid a tax to the Earls and Dukes of Cornwall. The blocks of tin were subjected to a process called "coining," and certain towns were fixed upon as *coinage towns*. The blocks of tin—rectangular masses—weighing about 3·34 cwt. each, were sent to the *coinage Hall*; a corner of each of the blocks was struck off (see *Coinage pieces* in case), and examined by Duchy officers appointed for the purpose, in order to see that the tin was of proper quality; the blocks were then stamped with the Duchy seal, the dues paid, and the blocks permitted to be sold. By an Act of Parliament of August 16, 1838, the duties payable on the coinage of tin in Devon and Cornwall were abolished. The Stannary Courts of Cornwall are now supported by a small tax upon all the ores raised in that county and in Devonshire.

The finer varieties of tin, known as *grain tin*, which are used principally by the dyers, are usually prepared by heating blocks of that metal in a bath of melted tin, which, at a certain temperature, are broken by a blow from a heavy hammer.

*Oxland's process for separating wolfram (a double tungstate of iron and manganese) from tin.*—This process was first introduced at Drake

Walls tin-mine near Tavistock. It consists in mixing with a little carbonate of soda, *tin whits*,—that is, the dressed tin from the stamps floors, ready for the burning house. *Whits* appear to signify *whites*, as indicating the white metallic look of the washed ore, from the presence of iron and of arsenical pyrites. The tin from the burning house is sorted into *jigged fluran*, that is, very small—*smals*, smalls—*slime* and *rows*, i.e. roughs. The mixture is then heated to redness in a reverberatory furnace, when tungstate of soda is formed, and the oxides of iron and manganese are liberated. The tungstate of soda, which is a soluble salt, is readily removed by water, and the oxides of iron and manganese are separated from the lixiviated tin by washing. The tungstate of soda is now collected and employed, amongst other things, for rendering textile fabrics non-inflammable. The tungstic acid in a state of purity has been used in the manufacture of steel. (See Table-case 51.)

*Ancient Bronze Weapons, &c.*—A few examples of these are placed with the tin for the purpose of showing that at a very early period the use of that metal as a substance capable of hardening copper, and producing therewith that useful compound metal, *bronze*, was known.

The art of casting bronze is traceable to the remotest antiquity, and nearly all the bronze celts, spears, arrow heads, and swords, together with bronze statues and coins which have been discovered, have a similar composition, and that the best, for producing the required degree of hardness. Ancient bronze weapons have usually been found to contain from 85 to 90 parts of copper in 100 parts, the remainder being mostly tin.

*Assyrian Bronze.*—Mr. Layard brought from Assyria the bronzes in this case, which were constructed for the purposes of support of some kind. Dr. Percy found that the bronze had been cast round a support of iron, by which means the appearance of considerable lightness was attained, while great strength was ensured. This discovery proves that the metallurgists of Assyria employed iron for the purpose of imparting strength to the less tenacious metals which they employed in their art manufactures. The bronze, as analysed in the Metallurgical Laboratory, consists of copper 88·37, tin 11·33.

#### ZINC SMELTING.

*Table-case 49.*—Agricola, and others in his age, regarded calamine as an earth containing no metal, although it had long been employed in the manufacture of brass. Van Swab in 1742, and Magraf in 1746, separated zinc from calamine by distillation in close vessels. Pott, in 1741, wrote a dissertation on zinc, in which he speaks of it as a semi-metal. The name zinc first occurs in Theophrastus Paracelsus. Agricola (*De Re Metallica*) calls it *contrefeyn*. Boyle names it *speltrum*. It was also called *spianter* and *Indian tin*. There is every reason for believing the story to be correct which refers our knowledge of the metallurgy of zinc to the Chinese. It is said that an Englishman took a voyage to China for the purpose of learning the art; that he returned and established works at Bristol, where zinc was obtained by distillation *per descensum*. Dr. T. Lawson appears to have been intimately connected with the early zinc works in this country; and to have associated himself with Mr. Champion, of Bristol, in the establishment for smelting calamine, about the year 1743.

The zinc ore, whether calamine or blende, is first roasted, and the oxide thus obtained reduced by smelting with carbonaceous

matter. In this country the reduction is effected in a crucible, provided at the bottom with a tube, through which the zinc vapour descends.

The celebrated Vieille Montagne ores have been noticed at p. 92. The Abbé Deny first established the smelting works, which passed into the hands of the Mosselman family in 1813, and in 1837 into the possession of the present proprietors, the Vieille Montagne Zinc Company. The distillation is conducted in a series of clay retorts, furnished with cast-iron conical condensers. A model of the furnace is exhibited in the gallery of the Model Room A.

Zinc is employed largely in the manufacture of brass, it is also used for covering sheet iron (*galvanized iron*) for baths, water tanks, and pipes; plates for the engraver, and for zincography, and a variety of other purposes, including the manufacture of the pigment *zinc white*, or oxide of zinc.

The extraction of zinc and preparation of the oxide as conducted by the Lehigh Zinc Company at Bethlehem, Pennsylvania, is well illustrated by a large suite of specimens presented by the company, and exhibited in the case before us.

#### BRASS.

*Table-case 49.*—In the arrangement of these table-cases we have first the pure metals, copper, tin, and zinc; then copper and tin, forming bronze; and finally copper and zinc, forming brass. This alloy is well known, and requires but little explanation.

For the production of differently coloured brasses, and to meet the required conditions of various manufacturing processes, the proportions of copper and zinc in brass are infinitely varied. A common proportion is 2 parts of copper to 1 of zinc. Formerly brass was manufactured by heating in crucibles a mixture of granulated copper, calcined calamine (carbonate of zinc), and ground coal. At the present day, however, the alloy is prepared directly by fusing together the proper proportions of copper and zinc either in crucibles or in a reverberatory furnace.

#### NICKEL AND GERMAN SILVER.

*Table-case 49.*—The metallurgy of nickel is usually kept a secret by the manufacturers. In Case 14 will be found some specimens illustrating the extraction of nickel in Sweden. The metal is produced in large quantities to meet the demands of the makers of German silver. Sheffield German silver has been found to contain 57 per cent. of copper, 24 per cent. of nickel, and 13 per cent. of zinc.

Several white metals bearing different names, such as nickel silver, albat plate, &c., are only varieties of the German silver. An ornamental casting in German silver, showing the character of the metal as it comes from the mould, is in Case 43.

#### SMALTS AND OTHER COBALT COLOURS.

*Table-case 49.*—The preparation of the beautiful cobalt-blues was discovered in Saxony about 1540, and it has since that time been carried on extensively in that country. The cobalt in the ores is converted into oxide by roasting, and the oxide of cobalt thus produced is vitrified with the addition of pure potash and silica. Since cobalt is usually associated with many other minerals, the processes connected with the preparation of smalt are of a delicate character. Smalt is a cobalt glass; this ground to fine powder and carefully

washed is applicable to all purposes in which a cheap and durable blue is required as a paint, and for giving a blue tint to paper or linen. Pure smalt may be used for painting and colouring glass and porcelain, but for delicate purposes the oxide of cobalt is employed. For colouring earthenware the roasted ore, with an addition of powdered flint, which is sent into the market under the name of *Zaffre* or *Saffor* (a corruption from sapphire), is employed; when mixed with the proper proportion of potash, the colour required is produced in the process of firing the ware. In this case will be found all the colours produced by chemical treatment from this metal. The silicate of cobalt and potash forms *smalt*, and *cobalt* or *Lickner's blue*; oxide of cobalt and oxide of zinc, *Rinman's green*; phosphate of cobalt with alumina, *Thenard's blue*; arsenite of cobalt, *purple*; and silicate of cobalt, *pink*.

#### PLATTNER'S GOLD PROCESS.

*Table-case 49.*—Plattner's method of gold extraction is, or at least was, used at Reichenstein, in Silesia, for the treatment of residues of arsenical ores (löllingite) containing about  $1\frac{1}{2}$  ounces of gold to the ton, and about 5 per cent. of arsenic. Some four hundredweight of these residues are treated with chlorine gas in glazed earthenware vessels for five or six hours. The chloride of gold produced by this means is then washed out with water, an operation that requires from six to seven hours. The free chlorine in the aqueous solution so obtained is neutralized with ammonia, and the gold separated by sulphuretted hydrogen gas as sulphide, which is reduced, by calcination, to metallic gold. The finely-divided metal is afterwards united by cupellation with lead.

Somewhat similar chlorination processes have been largely employed for extraction of gold in California.

#### ARSENIC.

*Table-case 49.*—The substances containing arsenic usually hold some sulphur in combination. The ores are placed on the sole of a reverberatory furnace, through which a current of air is allowed to play. The sulphur present is converted into sulphurous acid gas, and carried away by the chimney, while the *arsenious acid* (white arsenic) produced is condensed in chambers prepared to receive it. To obtain pure arsenious acid the first products thus directly obtained are subjected to a second sublimation in cast-iron tubes provided with cast-iron receivers.

A considerable quantity of the arsenic (arsenious acid) produced in this country is exported to Russia, and is used, it is said, largely in preparing some of the finer skins and furs. But the largest quantity of arsenic is employed in the manufacture of emerald green.

The preparation of many of the other less common metals, and their compounds, such as antimony, bismuth, cadmium, aluminium, &c., receives illustration in the Pedestal-case No. 46, immediately opposite to the table-case under description. For notice of the contents of Case 46, see p. 75.

The remaining table-cases of the metallurgical series stand in the three embayments on the opposite side of the room, to which therefore we now cross.

#### LEAD SMELTING.

*Table-case 50.*—The processes of smelting lead and of separating the silver from it were known at a very early period. The book of

Job, which is perhaps one of the earliest of the written records which have descended to us, clearly describes the metallurgical and mining processes; and in Jeremiah we find; "the bellows are burned, the lead is consumed of the fire; the founder melteth in vain. \* \*

\* Reprobate silver shall men call them." This passage proves the knowledge of the processes of desilverizing lead by oxidation, such as until of late years we have commonly employed. Ancient writers inform us that lead was found so plentifully, and so near the surface of the ground, that it was found necessary, in the earlier period of the Roman occupation, to make a law limiting the quantity to be taken each year. The traces of Roman lead mines are very extensive, and the discovery of Roman pigs of lead by no means uncommon. These were usually stamped with the name of the emperor under whose reign the lead had been produced. One of these Roman pigs of lead will be found in the collection, and two casts from other pigs which have been discovered. The original pig was one of fifty found in an old smelting work discovered near Orihuela, Valencia, Spain (Wall-case 44).

The following are the inscriptions upon the Roman pigs of lead:—

C·IVL·PROTI·BRIT·LVT·EX·ARG·

M·PRO·SCIEIS·M·F·MAIG

IMP·VT·SP·VII·T·IN·V·COS

LVT Mr. Wright conceives is an abbreviation of *lutum*, washed, and the EX·ARG· he thinks is explained by the following passage in Pliny, *Nat. Hist. lib. xxxiv.*—*Plumbi nigri origo duplex est; aut enim sua provenit vena, nec quicquam aliud ex se parit; aut cum argento nascitur, mistisque venis conflatur.* In *Pennant's Tour in Wales*, (Lond. A.D. 1810, 8vo., vol. i. p. 79.) will be found an interesting description of similar Roman pigs of lead.

The *ex argento* doubtless signifies that from the lead so marked the silver had been separated—that it was indeed refined or soft lead.

With a view to show as clearly as possible all the details of the processes by which lead is separated from its ores, freed of silver, and passed into the market, there are exhibited the various results of dressing, and of the smelting processes—and then the manufactured lead, as *sheet lead*, *shot*, and *lead pipes*.

Metallic lead is obtained either by simply roasting the galena, or native sulphide, under proper conditions, or by roasting the ore, and then reducing the oxidised products by means of carbonaceous matters, or finally by removing the sulphur from galena by heating it with metallic iron. The operations of lead smelting may be conducted either in reverberatory furnaces, in blast-furnaces, or in shallow hearths.

The process of desilverizing lead was formerly effected by oxidizing the lead, the oxide being from time to time removed from the furnace, leaving the silver upon the bed of bone ashes prepared to receive it. The oxide of lead has then again to be reduced to metallic lead; this process was in every way costly, and unless the per-centage of silver in the lead was large it was not separated.

A process is now employed which is known as Pattinson's process, the late Mr. Hugh Lee Pattinson having patented the method by which the lead is refined.

This chemist discovered that lead consolidated, or crystallised at a higher temperature than an alloy of lead and silver; consequently

that, if he kept lead containing silver in a state of fusion at the lowest temperature at which the fluid state could be maintained, solid masses were gradually formed, which when removed were found to be pure lead. Thus a large portion of lead in a state of comparative purity is removed, and the fluid portion which remains at the last is exceedingly rich in silver. In the MODEL Room B. will be found a drawing, and in A. a model of an arrangement of pots for carrying on the Pattinsonian process. The lead is treated in the manner described, the fluid portion becoming constantly more rich in silver; and this is passed from one pot to the other until, at last, the lead contains so much silver that it is not economical to carry this process any further. This lead is subjected to the oxidizing process and the silver separated.

While the old process was in use in the north of England, if the lead contained less than six ounces of silver to the ton, it was not found profitable to separate it; and in Wales, if it contained less than 12 ounces they did not refine the lead.

The cost of refining lead, previously to Mr. Pattinson's patent, was from 30s. to 60s. per ton. By Mr. Pattinson's process it is profitable to separate the silver when it does not contain more than three ounces to the ton. Beyond this more silver is now obtained from the lead than formerly; Pattinsonized lead never contains more than seven pennyweights of silver to the ton, when the process is properly performed, while the old refined lead seldom contains less than an ounce per ton, and frequently much more.

An interesting series of specimens is exhibited to illustrate Mr. Baker's process of softening hard lead, patented in 1860.

#### WHITE LEAD, &c.

*Table-case 50.*—A small group of specimens illustrating one of the processes employed for the manufacture of this pigment is here introduced. Metallic lead, cast into the form of gratings, is exposed to the action of the vapour of vinegar in beds of fermenting tan. The basic acetate of lead first formed is decomposed by the carbonic acid present, and in this way is obtained a carbonate of lead, which when purified by washing and levigation is ready for use as a pigment. When white lead is roasted it suffers decomposition, and the residuum, consisting of oxide of lead with a little carbonate, is employed under the name of *orange lead*. *Litharge* is obtained by oxidizing lead in a reverberatory furnace, and the product when further roasted forms the higher oxide known as *red lead*.

#### AMALGAMATION OF SILVER ORES.

*Table-case 50.*—The process of the amalgamation of silver ores as formerly practised at Halsbrücke, near Freiberg, is illustrated by examples of each stage of the process from the ore up to the formation of the amalgam of silver and mercury; and models of the apparatus employed will be found in the gallery of the MODEL Room A.

The process consists essentially in roasting the ore with salt (chloride of sodium). As the ores are usually of a very complex character, some complicated reactions ensue; the main result, however, being the conversion of the sulphide of silver into chloride of silver. This is mixed with mercury and some fragments of wrought iron, and, being placed in revolving casks, the mass is kept in motion for about 20 hours, when the amalgamation is complete.

## MERCURY.

*Table-case 50.*—Some mercurial ores from Idria in Austria, and from Hungary, are here associated with the metallic mercury and the vermilion prepared from it.

At Idria the sulphide of mercury is worked in a formation chiefly composed of black limestone associated with an argillaceous schist, with which it is so intimately mixed as to appear to have been formed contemporaneously with it. These mines were discovered in 1497. The workings are carried on by means of small galleries, as the rock is too pliable to admit of large excavations. The ore, which is principally bituminous cinnabar associated with native mercury, is obtained at a depth of 850 feet from the surface. On submitting the ore to distillation the sulphur is expelled, whilst the mercury is volatilized and collected in a series of condensing chambers.

If mercury is rubbed with sulphur in a mortar the black sulphide, *Ethiop's mineral*, is produced. If this powder be heated to redness it sublimes, and if a proper vessel be placed to receive the sublimed substance, a cake of a fine red colour is obtained, called *cinnabar*; this being reduced to powder forms the *vermilion* of commerce.

## IRON AND STEEL MANUFACTURE.

*Table-cases 51 and 52.*—In well-marked divisions in Case 52 the results of the processes of smelting the ores of iron are shown from the following iron works:—

<i>Whitehaven Iron Works</i>	-	-	-	Cumberland.
<i>Low Moor ditto</i>	-	-	-	} Yorkshire.
<i>Bowling ditto</i>	-	-	-	
<i>Farnley ditto</i>	-	-	-	
<i>Russell's Hall ditto</i>	-	-	-	South Staffordshire.
<i>Plymouth ditto</i>	-	-	-	} Glamorganshire.
<i>Dowlais ditto</i>	-	-	-	
<i>Maesteg ditto</i>	-	-	-	} Lanarkshire.
<i>Monkland ditto</i>	-	-	-	

It is not intended to give in this Guide Book any detailed account of the metallurgy of iron. The ordinary processes are, however, of the following order: The "*mine*," that is, the iron ore, is subjected to calcination. To effect this the ore may be piled in long heaps over a stratum formed of large lumps of coal. Fire is applied to the windward end, and after it has burned a certain distance the heap is prolonged with the same materials in an opposite direction. It is now common, however, to effect the calcination of the ironstone not in the open air, but in properly constructed kilns. The calcined ore is duly passed to the blast furnace.

In the Model Room the construction of a *blast furnace* can be studied with its associated *blowing machine*. In the blast furnace the proper mixture of iron ores and limestone is placed with a sufficient supply of fuel. The limestone (carbonate of lime) is used, as a *flux*, for the purpose of yielding lime to combine with the silica of the ore, thus forming a fusible double silicate of lime and alumina, which appears as a *slag*; while the iron is separated and collected in a fluid state at the bottom of the furnace, from which it flows out at the proper time and is collected in sand moulds prepared for it, producing the masses known by the name of "*pigs*."

As an intense heat is required for smelting iron ores, a strong *blast of air* is constantly injected through *tweyers* (iron nozzles connected with pipes leading from the blowing apparatus), which are

fixed in holes just above the level of the *tump*, or block of sandstone, which is adjusted at the base of the furnace, this blast being urged by a steam-engine constructed for the purpose. By employing heated air a saving is effected in the process of smelting, and it is now common to make the air traverse pipes which are heated by a separate furnace, before it enters the blast furnace. Iron prepared by the hot-air process is called *hot blast iron*, but when the air is admitted to the blast furnace cold it is known as *cold blast*.

The crude metal obtained from the blast furnace is termed *cast-iron*, of which there are three leading varieties:—

*Grey cast-iron*, exhibiting a finely crystalline surface.

*Mottled cast-iron*, lighter in colour than the grey, and presenting when broken a peculiar mottled appearance.

*White cast-iron*, hard and brittle, with a radiated lamellar fracture.

Cast-iron in all its varieties contains a considerable amount of carbon, sometimes as much as five per cent., together with small quantities of silica, sulphur, phosphorus, &c. These impurities are oxidized during the conversion of the cast-iron into *wrought* or *malleable iron*. This is effected by taking advantage of the fact, that though iron and carbon are both combustible, yet carbon is the more so of the two; if, therefore, iron is melted in a reverberatory furnace and exposed to a current of air the carbon is, to a large extent, burnt out. The operation is called *puddling*, and instead of relying entirely on the action of the air to remove the excess of carbon, a variable proportion of the oxide of iron or of manganese is commonly employed. As the carbon passes off as carbonic oxide the iron becomes less fusible, and ultimately breaks up into an incoherent granular mass like sand. The heat is then increased, these grains agglutinate, and being worked up into a ball, the mass is taken from the furnace, and subjected to great pressure by machinery. The lump of malleable iron thus obtained is then passed through a succession of rollers, turned by a powerful steam engine, each pair of rollers having a smaller interval than the preceding; by this means the mass is gradually elongated into a bar, and at the end of the rollers furthest from the furnace it passes out as the soft bar iron of commerce. Some fine examples of such iron will be found in the entrance hall. In the ordinary operation of puddling, the charge is constantly *rabbed* or stirred by the puddler in order to bring every portion of the metal to the surface. To avoid the great physical exertion thus required of the workman several methods of mechanical puddling have been introduced. The most notable of these is the revolving furnace of Mr. Danks, in which the molten pig-iron is agitated and brought in contact with heated air by the rotation of a moveable chamber.

Whilst pig-iron is always brittle and exhibits a more or less crystalline structure, the puddled iron after being duly hammered and rolled is extremely malleable and presents on fracture a decidedly fibrous texture. Some specimens in *Case 51* are interesting as illustrating a *supposed alteration in the structure of wrought-iron by vibration*. Attention was directed to the influence of long-continued vibration on the structure of iron by Mr. Nasmyth in 1842. His experiments went to prove that an original fibrous or ligneous structure was changed into a crystalline one. The process of "*cold swaging*" was found to produce this molecular disturbance to so great an extent as to render the iron liable to break with the slightest blow. Mr. Lucas, between this and 1844, made a great many experiments which appeared to prove that long-continued vibration certainly produced this effect, and not only that iron but

that even wood was subject to this weakening influence. Some engineers have, however, questioned the facts brought forward, and are disposed to think that the fracture is dependent upon the kind of blow with which the iron is broken;—a dull blow producing a fibrous, and a sharp one a crystalline fracture.

A *railway axle*, as bent by an accident without breaking, and some examples of peculiarities in construction, will be found in the Model Room A.

**STEEL MANUFACTURE.** *Table-case 51.*—Steel may be regarded as representing a condition intermediate between cast iron and wrought iron. Its principal characteristic is its capacity of being hardened or softened by rapid or slow cooling. The proportion of carbon which is present varies considerably in different varieties; mild steel may not contain more than 0·3 per cent., whilst the harder tempers may contain nearly 2 per cent.

Steel is sometimes formed directly from the ore, as in the Catalan forge; more frequently it is obtained by adding carbon to malleable iron, as in the old process of cementation; whilst often again it is produced by the decarbonization of pig-iron, as in the Bessemer process. As the Bessemer process has been described at page 62, in connexion with the model No. 18, it will be sufficient here to refer to the old process of cementation, which is well illustrated by specimens in the case before us: it will not be forgotten that a model of steel works at Sheffield working this process, stands at the northern end of the room No. 21, and is noticed at p. 64.

In the *cementation process*, bars of iron are imbedded in powdered charcoal in boxes, and exposed for a long time to a full red heat. To prevent the charcoal from burning away, and to confine its action as much as possible to the iron, the whole is covered with some sand or earth which will not easily vitrify. In Sheffield a stiff ferruginous mud, called *wheelsharf*,—the stuff which is produced by the wearing of the grindstones,—is generally used, and every unnecessary aperture is carefully closed. The trough containing the iron and charcoal, which holds from 13 to 17 tons of metal, is then exposed to the action of fire, which is maintained at a high intensity for some days.

*Blistered Steel* is produced by the formation within the mass of a gaseous compound of carbon and oxygen, which occasions the formation of bubbles in the metal.

*Shear Steel.*—Blistered iron bars are bound together, and being placed in a wind furnace brought up to a welding heat, the bars are formed by heavy hammers into a rod about 2 inches square; it is then cut in the middle, the two halves placed together, and welded again as before. By this process the steel is not liable to the flaws so frequent in blistered steel. As the welding may have been more or less frequently repeated, so the value of the steel varies, and it is known in the metal market as *half shear*, *single shear*, or *double shear*. *Faggot steel* is manufactured by a process analogous to that of shearing.

*Cast Steel.*—Blistered bars are broken into small pieces and put into a barrel-shaped crucible of Stourbridge clay, capable of holding about thirty pounds of metal. This is placed in a draught furnace, which is fed with the best coke, and every means adopted for producing a very high temperature. In about four hours the fusion is complete, and, being withdrawn from the fire, the molten steel is poured into a mould. Great attention is required in this process, the quality of the steel depending entirely upon the management of the melter.

*Sheet and Bar Steel*, for saws, &c., is made by repeatedly passing the metal at a red heat through large metal rollers. *Bar Steel* is made in a similar manner, the rollers being grooved to form either flat or round bars. An examination of the *Model of a Sheffield Steel Manufactory* (No. 21) at the north end of this Museum, which includes the *furnaces, rolling mills, and forge*, will aid the visitor in forming a correct idea of the processes of steel manufacture, which are here so very succinctly described.

In the Model Room A, against the wall to the right hand of the visitor on entrance, is a stand containing *specimens of every variety of steel sent into the market* at the time of the Great Exhibition of 1851. These, and the model, were presented to the Museum by Messrs. Naylor, Vickers, & Co., of Sheffield.

*Hardening and Tempering*.—Steel is commonly *hardened* by being plunged, when red hot, into water; it is afterwards *tempered* by being heated until the surface assumes a tinge varying from a light straw colour to a deep blue. An interesting series of *specimens of steel at the different colours for tempering* will be found in this case. The process of tempering steel is one demanding the most exact attention from the manufacturer.

Before leaving this Case attention should be called to a series illustrating the production of steel and malleable iron from fusion of pig-iron and hematite by *Clay's process*. There will also be found several examples of *Mushet's tool steel*, and numerous fragments of steel *shot and armour plates*. In connexion with steel manufacture it should be remarked that some magnificent examples of *Bessemer steel* will be found in the lower compartment of Pedestal-case No. 7, and also in the case containing the Bessemer model No. 18. A sample of *Whitworth steel* is placed temporarily in the lower part of Case No. 8; and a specimen of *Siemens' steel* will be found in the case before us (No. 51), whilst a model of Siemens' furnace, in which cast-steel and iron are produced directly from the ore, is exhibited in the gallery of the Model Room A.

The metallurgical series has of late years outgrown the six table-cases to which it was formerly restricted, and it has consequently been found necessary to devote several cases in the central area to this department of the collection. It is, however, unnecessary to allude further to these cases, since they have already received notice at pp. 59, 60, 75, &c.

## HORSE-SHOE CASE.

### NON-METALLIC MINERALS AND THEIR APPLICATIONS.

Formerly the collection of non-metallic minerals was confined to a large glass case, of horse-shoe form, running round a similarly-shaped space in the centre of the room, which admits light to the Lecture Theatre situated below. A few years ago, however, it was found necessary to extend this case by adding others, which are supported on the cornice of the balustrade surrounding the opening from the principal floor to the lower hall. The original case was divided into 16 compartments or separate cases; 12 others have been added, thus making a series of 28 sections, each equivalent to an independent case. These 28 cases form a closed series, somewhat D-shaped; but though the collection has thus lost its horse-shoe form, its original name may still be conveniently retained.

In the horse-shoe case, therefore, the visitor will find all the gems

and ornamental stones, the spars, and earthy minerals. These are grouped together under the general term of "non-metallic," in conformity with popular usage and practical convenience; but the visitor will bear in mind that whilst many of the species here exhibited are strictly destitute of metal, such as the diamond, by far the larger number contain some metallic element, principally, however, the rarer metals of low density, such as potassium and aluminium, and never the common heavy metals of commerce.

Each case, or separate compartment of the horse-shoe case, will now be described, commencing with the case at the south-east corner of the series.

#### CASE A.—DIAMOND.

From the high refracting power of the diamond, Sir Isaac Newton conjectured that this beautiful gem might be a combustible body. In the heat of the oxyhydrogen flame, and in oxygen gas, the diamond has been burned, producing only carbonic acid gas, and leaving a small quantity of ash; and by the electric arc it has been converted into a coke-like mass, thus proving that this hard transparent body is only carbon in a peculiar form.

Diamonds are found naturally crystallized, the forms always being related to the cube; the faces are usually rounded as seen in many of the crystals exhibited. Diamonds have been, through all time, discovered in the East Indies, especially in the kingdoms of Golconda and of Visapour, but the largest supply until lately was obtained from the mines of Brazil, where they occur chiefly in a deposit called *cascalho*, consisting principally of fragments of quartz and ferruginous sand: a sample of this *cascalho* is shown. Unparalleled discoveries of diamonds have, however, been made within the last few years in South Africa. The first diamond was found in the Colesberg district in 1867, and was sold for 500*l.*; a model of this stone is exhibited. Large numbers of diggers were soon attracted to the fields, and their labours rewarded by the discovery of vast numbers of diamonds, including many of unusual size.

The largest yet discovered is the celebrated "Stewart," of which a model will be found in this case; the original weighed 288*½* carats, and was found at Waldeck's plant on the Vaal River. Like a large proportion of South African diamonds, the Stewart exhibits a pale straw tint. The African diamond workings are of two kinds, known as the "river diggings" and the "dry diggings"; specimens from both are here exhibited. The river diggings are in deposits of gravel, rich in pebbles of jasper, agate, &c.; whilst the dry diggings are generally opened in disintegrated material occupying pipes which break through the Karoo shales. The diamonds are occasionally found attached to fragments of associated rocks, and several of such stones in the "matrix" will be found among the specimens in this case. There are also exhibited numerous examples of the pebbles and other materials among which the African diamonds are found, whilst the character of the workings at the great Colesberg Kopje is well shown by the photographs at the back of the case.

Many of the largest known diamonds which have acquired historic interest are here represented by models, among which those of the celebrated Koh-i-noor claim especial attention. This diamond is, according to Indian traditions, more than 4,000 years old, having been found in the mines in the south of India in the days of the great war celebrated in the heroic poem, the *Mahābhārata*, and was worn by one of the warriors who was slain on that occasion. The *Rajah of Ujain*, 50 B.C., is said to have had possession of this

gem, and it remained with his successors until it fell into the hands of the Mohammedan conquerors of India.

In 1665 this jewel was examined by Tavernier in the cabinet at Delhi, and in 1739 Nadir Shah, on his occupation of Delhi, obtained possession of it. After his death the diamond, which he had wrested from the unfortunate representative of the house of Timur, became the property of Ahmed Shah, the founder of the Abdali dynasty of Kabul, who probably took it from Shahrikh, the young son of Nadir Shah. The jewel descended to the successors of Ahmed Shah, and was worn by Shah Shuja on his arm. When Shah Shuja was driven from Kabul he became the prisoner of Runjet Sing, who compelled the fugitive monarch, in 1813, to resign the precious gem for, it is said, a lakh and twenty-five thousand rupees, above 12,000*l.* sterling. Runjet wore the diamond as an armlet on all great occasions; after his death it was worn by Rhurreuk Shing and Shu Shing. After the murder of the latter it remained in the Lahore treasury until the supercession of Dhulip Sing, and the annexation of the Punjaub by the British Government, when the civil authorities took possession of the Lahore treasury, under the stipulations previously made that all the property of the State should be confiscated to the East India Company, and that the Koh-i-noor should be given to the Queen of England. In order to bring out its lustre and remove some flaws, this gem was re-cut after the Great Exhibition of 1851, under the direction of Messrs. Garrard, and since the cutting its beauty has been greatly enhanced.

In this case will also be found models of the following diamonds, the weights and approximate values of which are expressed on the accompanying labels:—The Rajah of Mattan's; the Star of the South; the Mogul; the Regent, Pitt, or Orleans; the Orloff, or Russian; the Tuscan; the Florentine, or Austrian; the Hope; the Dresden; the Nassuck; the Pigot; the Shah; the Sancy; the Eugénie; the Polar Star; the Cumberland; the Stewart; the first diamond found in S. Africa; Mr. Dresden's; the engraved Persian; and a diamond said to have been worn by Napoleon in the hilt of his sword.

The impure variety of diamond called *bort* or *boort*, which occurs usually in small spherical nodules, having a radiated internal structure, is employed, in the state of powder, as a grinding and polishing agent; and the dark-coloured non-crystalline substance called "*carbon*" or *carbonado* receives a similar application. The latter is a peculiar form of carbon, discovered in the diamond gravels of Brazil in 1842, and appears to furnish a transition from ordinary diamond to the next species—graphite.

#### CASE B.—GRAPHITE, &c.

The mineral known variously as *Graphite* (*γραφω*, *grapho*, I write), *Plumbago* (*Plumbum*, lead), and "*Blacklead*," is composed of carbon and a small but variable quantity of iron; it has, however, no chemical relation to lead, as some of its names might suggest. It occurs in beds and imbedded masses, in granite, slate, and crystalline limestone, and in nodules in greenstone. It is occasionally found crystallized in thin six-sided plates; and a similar form is assumed by the *artificial graphite* or "*Kish*" formed during certain metallurgical operations. Examples of this are exhibited.

The plumbago from Borrowdale in Cumberland has long been celebrated for its fine quality, but the supply is very irregular, the

mineral being found only in detached pieces, called, according to their size, *sops* or *bellies*. Some years since a very large quantity of plumbago was obtained from Borrowdale; this has been stored by the proprietors, and sold in small parcels from time to time. The mine was not worked for several years, but has been reopened lately.

The application of plumbago to the manufacture of crucibles having been already noticed (p. 46), it remains only to mention its use in the preparation of *black lead pencils*, as illustrated in this case.

Pencils are of three qualities,—*drawing pencils*, *prepared pencils*, and *composition pencils*. Pencils of the *first quality* are made of pure Cumberland plumbago, which costs about 168*l.* per cwt. They are made by sawing the "*lead*" into pieces, and inserting them in the cedar. A pound of plumbago will produce about 18 or 20 dozen of pencils.

Pencils of the *second quality* are manufactured out of the sawings or dust of pure black lead, and the small pieces which could not be cut into pieces of sufficient length; this is mixed with a certain quantity of antimony. The antimony is frequently in large excess above the black lead, the former costing only 26*s.* the cwt., the latter 100*l.* The *third quality* of pencil is made with Mexican or Spanish plumbago and antimony, sulphur being added to produce the blacker pencils.

By *Brockedon's Patent*, illustrated in this case, the smaller pieces of the Cumberland plumbago, which are too small to be cut into slices for pencils, but are yet of very fine quality, are ground to an impalpable powder, which is subjected to enormous pressure, imparted by means of a screw press. The result of this is that the plumbago powder is rendered perfectly coherent. From the blocks thus formed, some of which are shown, slices are sawn, from which pencils of the best quality, and entirely free from grit, are formed. The fracture of this compressed plumbago precisely resembles that of the natural graphite.

In addition to the Cumberland graphite, specimens of the mineral are exhibited from Siberia, Ceylon, and Canada, as well as from several other localities of much less commercial importance.

The remainder of this case is occupied with some of the forms of *coal*, which are rich in carbon. The "*mother of coal*" or *mineral charcoal*, which often occurs between the layers of bituminous coal, is a soft fibrous material, readily soiling the fingers; it contains between 75 and 83 per cent. of carbon. The varieties of *coke* represent the carbonaceous constituents of coal as obtained artificially by processes of destructive distillation. There are also some samples of the so-called "*graphite*," or *gas-carbon*, found lining the interior of gas retorts, and valued as a conductor of electricity; it is sawn into pencils to form the poles between which the electric light is produced, and it is also used as the negative element in Bunsen's battery.

The varieties of coal, occupying part of this case and of the next, form a regular series, commencing with the non-bituminous stone-coal or anthracite, and passing thence through the ordinary bituminous coals to the recently-formed lignite or brown coal, in which the original structure of the wood is frequently retained. The probable mode in which coal has been formed is noticed at p. 174.

*Anthracite* always contains a large quantity of carbon, frequently upwards of 90 per cent., and but a small proportion of volatile constituents. As the anthracites become softer they are distinguished

as *free-burning coals*, and these may pass into the ordinary *bituminous* varieties, as in the South Wales coal-field.

The "*crystallized*" coal exhibits a very peculiar structure, known as *cone-in-cone*; and in the *peacock coal*, provincially called *moontons*, we have a remarkable example of the influence of surface arrangement in producing colour.

#### CASE C.—COAL, JET, AMBER, &c.

A large part of this case is occupied by a continuation of the series of coals, and by various hydrocarbons more or less closely related to this series.

*Cannel* is usually regarded as a hard, compact variety of bituminous coal. It burns readily without melting, with a clear yellow flame, and it has been used as a substitute for candles, whence its name, *candle*, or, in local patois, *cannel* coal. Large quantities are raised near Wigan in Lancashire, and at Lesmahagow, about twenty miles from Glasgow, where it is made into inkstands and other ornamental articles. A fine block of Lancashire cannel stands in the Lower Hall, No. 50.

The *Albertite* from Nova Scotia appears to be an asphaltic variety of cannel, but its right to be called a "coal" is certainly questionable.

*Lignite* or *brown coal*, which frequently retains the original texture of wood, usually occurs in deposits of tertiary age. In Germany lignite is extensively worked, but in this country it is raised only at Bovey Tracey, in Devonshire, where it occurs in beds of miocene age. The value of lignite as a fuel is far inferior to that of ordinary pit-coal. The miocene plants from the Bovey-Tracey cannel will be found in the Upper Gallery, Case 52.

*Jet* appears to be a compact variety of lignite. At Whitby the jet occurs in the upper-lias shale, from which it is collected with great labour. It is also found on the shore, being frequently thrown up after storms. Much of the common jet is now imported from Spain. Jet is the *gagates* of Pliny, a name derived from the river Gagas in Syria.

With the coals are introduced a few minerals, or rather rock-substances, which, although differing essentially from coal, nevertheless possess considerable economic value. Of these the most interesting is the *Torbane Hill mineral*, or "*Bog Head cannel*," found in the coal-measures of Linlithgowshire. From this substance, which is well known as having been the cause of considerable litigation, are obtained, by distillation at a low temperature, certain hydro-carbons highly valued, partly for illuminating purposes and partly as lubricating agents. It is now, however, virtually worked out, and recourse is had to other shales in the district.

The so-called *Kimeridge coal* is a bituminous shale occurring in the Kimeridge clay of Dorsetshire. When heated to redness in the open air the organic matter is slowly burned away with a smoky flame, and a bulky ash remains, consisting principally of alumina, the quantity of which is so large that some of the shale has been used as a source of alum, and a former possessor of the property erected works for this purpose. If, instead of being heated to redness in the open air, the shale be heated in a close vessel, a variety of valuable gaseous or liquid compounds may be distilled off. Small circular discs of this Kimeridge shale are frequently found in the Isle of Purbeck, and from their supposed use pass under the name of *Kimeridge coal money*, but it is more probable that they

are simply the refuse-pieces from which rings or armlets have been turned.

The remainder of this section is occupied by certain organic compounds, which require no very special description. *Hatchettine* or *mineral tallow* is a hydro-carbon occurring in the nodules of clay ironstone from the South Wales coal-field; and *Ozokerite* or *mineral wax* is a substance of very similar composition, found in considerable quantity in Moldavia, where it is applied by the peasants to a variety of purposes, and whence it has of late been largely imported for the production of paraffin and the manufacture of candles by Messrs. Field & Co. Closely related to these are the substances grouped together under the general name of *Bitumen* or *mineral pitch*. The compact variety called *Asphalt* is represented by specimens from the mountain limestone of this country, and from the celebrated Pitch Lake of Trinidad. This lake is one and a half miles in circumference; the bitumen is solid and cold near the shores, but gradually increases in temperature and softness towards the centre, where it is boiling. The solidified bitumen appears as if it had cooled as the surface boiled in large bubbles. The ascent to the lake from the sea, a distance of three quarters of a mile, is covered with a hardened pitch, on which trees and vegetables flourish; and about Point la Braye the masses of pitch look like black rocks among the foliage; the lake is said to be underlain by a bed of mineral coal.

The *Elaterite* or *mineral caoutchouc* is a soft elastic variety of bitumen having a peculiar odour, and occurring in the carboniferous limestone of Derbyshire, where it was first observed, at the forsaken lead mine of Odin, by Dr. Lister, in 1673. Passing over a small group of mineral resins, found chiefly in deposits of lignite, the only other mineral which need be noticed in this section is the well-known substance *Amber*.

The vegetable origin of amber is now fully ascertained. This is inferred both from its native situation with coal, or with fossil wood, and from the occurrence of insects and other organisms encased in it. Of these insects some appear evidently to have struggled after having been entangled in the then viscous fluid, and occasionally a leg or a wing is found some distance from the body, which had been detached in the effort to escape. Göppert has named the tree supposed to have yielded most of the amber *Pinites succinifer*. The principal supply of amber is obtained from the Prussian coast of the Baltic. It is also found in Sicily.

Such are the examples of natural substances belonging to the carbon group, commencing with the most brilliant of gems, passing through all the varieties of coal, and terminating with another substance used for ornament, amber.

The coal-fields of England are the most important in the world, the production from British collieries during the year 1874 having reached the prodigious amount of 125,000,000 tons.

#### CASE D.—NATIVE SULPHUR.

Sulphur is one of the most widely diffused chemical elements in the economy of nature. In a free state it occurs chiefly in volcanic districts; Sicily and the neighbouring volcanic islands, and the Solfatara, near Naples, being the great depositories from which it is obtained. There are also important deposits in the Romagna and in Spain; whilst the sulphur of Iceland has recently attracted attention commercially. Most of the sulphur-yielding localities are well represented in the case before us, and several of them have

contributed finely-crystallized specimens. The visitor will especially note the large crystals from the Romagna, from Spain, and from Sicily, where the sulphur is associated with celestine and gypsum.

#### CASE E.—PREPARED SULPHUR.

The extraction of sulphur from the impure native materials, and the properties of the prepared sulphur, are illustrated in this case. As native sulphur is usually contaminated with earthy matters, it is purified by a simple process of distillation. Sulphur is also largely extracted from iron pyrites (p. 108), a bisulphide of iron, which yields a considerable proportion of free sulphur on simple distillation.

At ordinary temperatures sulphur exists as an opaque solid of specific gravity 1.98. It melts at 226° Fah. to an amber-coloured liquid; if the temperature be then raised to about 400° Fah. it becomes dark brown, opaque, and so thick that the vessel containing it may be inverted without its running out; but heated yet higher it again becomes thin and limpid. If the thick tenacious sulphur at 400° be suddenly cooled by immersion in a large quantity of water, it forms a soft and transparent mass of considerable elasticity. In this state it is used for receiving impressions of seals, &c.; after some time it changes into its ordinary state.

The crystals of native sulphur, and those prepared by evaporation from solution at ordinary temperatures, are entirely distinct in form from the crystals which may be obtained by solidification from a state of fusion; and this difference in crystalline character is accompanied by a corresponding variation in density and other physical properties.

With the sulphur-group will be found a fine specimen of the closely-allied but much less widely-diffused element, *selenium*, as prepared from the deposits of the copper-smelting furnaces of Mansfeld (p. 111).

#### CASE F.—SALTS OF SODIUM; BORACIC ACID.

A large specimen of crystallized *sodium* is exhibited in connexion with the aluminium-series on the opposite side of the room; and another specimen is placed here as representing the metallic base of a group of minerals which occupy a prominent position in this section. Of these salts of sodium, the most important is the chloride or *common salt*. The greater part of our culinary salt is manufactured from the brine springs of Cheshire and Worcestershire, which rise probably from beds of *Rock salt*. The rock salt itself is largely worked at Northwich, in the valley of the Weaver, and near Belfast, in Ireland. A thick bed has been pierced at a considerable depth at Middlesbro'-on-Tees. The rock salt of Cheshire occurs in stratified deposits near the base of the New Red or Keuper Marls, associated with gypsum. Occasionally the salt is colourless and crystalline, but usually it is coloured to a greater or less extent by the presence of peroxide of iron. Although generally found in the New Red Sandstone, rock salt is by no means confined to this formation; the deposits, for example, of Wieliczka, in Poland, and Volterra, in Tuscany, occurring in tertiary marls: from both these localities specimens are exhibited.

The curious hopper-shaped crystals of salt here shown result from the aggregation of a number of small cubes formed on the surface of the brine during evaporation.

The Greenland mineral called Cryolite or ice-stone is a double

fluoride of aluminium and sodium, which has been already noticed as a source of aluminium (p. 76).

The few remaining salts of sodium, here exhibited, require no lengthened description. Attention should, however, be directed to the unusually fine crystals of the rare mineral called *Glauberite*, a double sulphate of soda and lime, from Spain. The deliquescent nitrate known as *Cubic nitre* is employed as a source of nitric acid, and in other ways as a substitute for saltpetre; while the borate of soda or *Borax*, known in its crude state as *tincal*, is largely used for soldering, and for glazing pottery. From borax we pass to *boracic acid*, of which a small groups of specimens is here introduced.

This acid, a compound of boron and oxygen, is obtained for the arts from the volcanic fumaroles of Tuscany. The first locality known was at *Sasso*, whence the name *sassolin*. The lagoons of Tuscany spread over a surface of about 30 miles, and clouds of vapour are constantly seen rising in large volumes among the mountains. As they are approached the earth appears to pour out boiling water, as if from volcanoes of various sizes, the heat in the immediate neighbourhood is intolerable, and the vapours suffocating; the vents for the vapour are termed *soffioni*. These hot vapours, which contain only a small proportion of boracic acid, are made to pass through water, by which the acid is absorbed. This weak solution gradually becomes more highly charged, as it is transferred from one lagoon to another, and, when sufficiently impregnated, the solution is evaporated by means of the steam from the springs. The specimens exhibited are from the works of the late Count Larderel, whose name deserves record as the founder of this branch of industry in Tuscany.

Among the salts of boracic acid may be noticed *Hayesine*, a borate of lime, occurring in white reniform masses, scattered over the dry plains of Iquique in Southern Peru, where it is called *tiza*.

#### CASE G.—SALTS OF POTASSIUM, MAGNESIUM, &c.

Of the salts of potassium only a small number occur native. The chloride of potassium, corresponding to rock salt in the sodium series, was an extremely rare species until found a few years ago in the salt-deposits of Stassfurt in Prussia. Some fine crystals of this mineral, known as *Sylvine*, are here exhibited. The nitrate called *Nitre* or *saltpetre* is of considerable value, being extensively employed in the manufacture of gunpowder. In the East Indies and in Ceylon a great number of nitriferous caverns exist, but the spontaneous generation of nitre in India, Egypt, Spain, and elsewhere is insufficient to supply the wants of the world, and a large quantity is therefore prepared artificially. Nitrate of potash crystallizes in six-sided prisms, with four narrow and two broad faces, as may be well seen in the artificial crystals.

*Alum* is placed here as a salt containing potash and alumina in combination with sulphuric acid and water. Such at least is the composition of ordinary alum, but in other varieties the potash may be replaced by soda or other protoxides; indeed of late years the manufacture of ammonia-alum has largely superseded that of the potash salt. Alum was long manufactured on a large scale from the *alum slate* or *shale* of Whitby. On roasting this shale, the disseminated iron pyrites undergoes decomposition, a portion of its sulphur being converted into sulphuric acid, which forms a sulphate of iron and alumina, and on decomposing this by a salt of potash common alum

is obtained. The shale in various stages of decomposition and some fine alum crystals are here shown. The manufacture of Whittby alum is, however, almost discontinued.

The Hungarian *alumstone* is an altered trachytic rock, not only used as the source of a very pure alum, but also employed occasionally as a millstone.

*Websterite*, a sulphate of alumina, discovered by Mr. Webster, the geologist, at Whitehaven, in Sussex, is represented by various specimens which have gained admission here simply by their rather remote relationship to the alum group.

An interesting series of minerals from the salt-deposits of Stassfurt is placed in this case. Borings for rock-salt in the neighbourhood of Stassfurt, near Magdeburg, in Prussia, revealed the existence, some few years ago, of vast deposits of various salts of potassium overlying the sodium salts. This represents precisely the order in which they would crystallize from a solution containing both kinds of salt; the salts of sodium being less soluble than those of potassium and magnesium would separate first, leaving the more soluble compounds in the mother-liquor. The discovery of the *Kalialz* of Stassfurt has entirely changed the sources from whence the chemist derives his supply of potash salts; it has developed very flourishing local industries, and has furnished to the mineralogist several new species which are represented in the case before us.

In this section are also placed a few minerals containing *magnesium*, such as *Brucite* and *Epsomite*. Although magnesium was discovered by Sir H. Davy in 1808, it is only by Mr. Sonstadt's comparatively recent improvements in its manufacture that it has been obtained in quantity sufficient to render it of commercial importance. By the action of hydrochloric acid on carbonate of magnesia there is obtained a chloride of magnesium, from which the metal is reduced by the action of sodium. Examples of the metal will be found in Case No. 46.

#### CASE H.—SALTS OF BARIUM AND STRONTIUM.

The very widely diffused mineral *Barytes*, or sulphate of baryta, is frequently employed as a pigment, either alone or associated with white lead; and for this purpose the mineral is raised in Derbyshire, the Isle of Arran, and other places. From its density barytes is commonly known as *heavy spar*; while the massive earthy varieties often pass under the name of *cawk*.

*Witherite*, a carbonate of baryta, named after Dr. Withering, occurs in remarkably fine crystals at Fallowfield mine, near Hexham, in Northumberland.

Carbonate of baryta combines with carbonate of lime, forming a double salt, which, occurring in two distinct series of crystalline forms, gives rise to the two species *baryto-calcite* and *alstonite*.

The earth *strontia*, closely allied to *baryta*, occurs in the form of sulphate and carbonate. The sulphate called *Celestine*, from the pale blue colour which it occasionally presents, occurs in fine crystals at Girgenti, in Sicily, associated with native sulphur; and in the neighbourhood of Bristol, in the New Red Marl.

The carbonate known as *Strontianite* is found in the lead mines of Strontian in Argyleshire, a locality which has given its name to the mineral.

The salts of strontia are remarkable for the red colour which they impart to flame, those of baryta giving a green tint.

## CASE I.—GYPSUM, &amp;c.

In connexion with the case in the lower Hall, illustrating the applications of *plaster of Paris*, this salt of lime has already been described (p. 43). The crystalline character of *Gypsum*, or, as the transparent varieties are called, *Selenite*, is well shown by the perfect crystals which not unfrequently occur in deposits of clay and marl; a characteristic twin-form being seen in the fine arrow-headed crystal from the celebrated quarries of Montmartre, near Paris. The beads and other objects of *fibrous gypsum* exhibit in a marked degree the pleasing lustre which has led to the name of *satin spar*; whilst the carving executed by Mr. Jordan's machinery illustrates the application of the variety called *alabaster*, described at p. 34. The waterless sulphate of lime, *Anhydrite*, has been already noticed (p. 43).

## CASE J.—CALCITE.

Some idea of the great variety of forms assumed by this widely-distributed mineral will be gained from the numerous crystallized specimens grouped together in this section. On fracture, the crystals of calcite split with the utmost ease into regular six-sided solids, called rhombohedrons; and it was indeed in this species that the property of cleavage in minerals was first observed. Calcareous spar is a carbonate of lime, containing, in a state of purity, carbonic acid, 44; lime, 56; but it often contains impurities upon which depend the colours assumed by the mineral.

The highly transparent varieties are termed *Iceland spar*, the finest specimens being obtained in Iceland. This crystal is remarkable for its double refraction, the phenomena of which are well shown in the specimens exhibited. The power of refracting light doubly is, however, enjoyed in a greater or less degree by all crystalline minerals, except those belonging to the cubic system.

CASE K.—CARBONATE OF LIME, *continued*.

Many of the massive forms of carbonate of lime having been already described in connexion with the *marbles* (p. 30) and *limestones* (p. 37) in the Hall, it only remains to notice among the marbles here exhibited—the *giallo antico*, or yellow marble of Sienna, generally known as *Sienna marble*; the *onyx marble*, from Algeria and Mexico, a stalagmitic form similar to the "alabaster" of the ancients; and the *fire marble*, or *lumachella*, from the lead mines of Bleiberg, in Carinthia, remarkable for the brilliant iridescence of its fossils.

The Derbyshire inlaid marble work in imitation of Florentine mosaic is sufficiently explained by the descriptive labels attached.

The *Fontainebleau sandstone* or *limestone* is an aggregate of rhombohedrons of carbonate of lime, containing a large quantity of sand mechanically mingled.

In connexion with the varieties of carbonate of lime will be found some interesting examples of the production of *pearls* on the shell of the pearl oyster and pearl mussel, by the artificial process of introducing some object which will produce irritation to the mollusc.

A very distinct physical condition of carbonate of lime is presented in the mineral called *Aragonite*, from having been first discovered at Aragon, in Spain. In addition to the fine rhombic crystals may be noticed the coral-like stalagmitic forms occurring chiefly in the *iron mines of Styria*, and known as *flor ferri*, or "*flower of iron*."

## CASE L.—DOLOMITE; APATITE.

Carbonate of lime frequently contains a variable amount of carbonate of magnesia, and when the two compounds occur united in nearly equivalent proportions, they form the species *Dolomite*, already described among the building stones (p. 39). As the proportion of magnesia increases, the species passes into *Magnesite*, or carbonate of magnesia.

The remainder of this case is occupied with a series of specimens illustrating the varieties and mode of occurrence of the valuable mineral called *Apatite*.

In different varieties the composition of apatite varies, but it consists essentially of phosphate of lime associated either with a chloride or fluoride of calcium, or with both. This mineral is not unfrequently found in company with tin ores. The extensive use of phosphate of lime as a fertilizer gives considerable commercial value to the deposits of this mineral occurring in Spain, Nassau, Norway, and Canada. A fine example of Canadian apatite is exhibited in the Hall, No. 168, p. 48. The massive varieties are frequently called *Phosphorite*. With the minerals in this case are grouped a few other phosphatic substances applied to similar purposes. In the lias, greensand, and other secondary formations numerous *coprolites* and phosphatic nodules occur; and in some of the Craggs of our eastern counties they are also found, with various mammalian and other animal remains. By the action of sulphuric acid these are converted into super-phosphate of lime, in which form they are largely employed for manure. Valuable phosphatic deposits have also been discovered in North Wales. The well-known Peruvian *guano* and the West Indian *sombrerite* find a place in this group.

## CASE M.—FLUOR SPAR.

The species *Fluor spar* is here represented by a number of specimens, not less attractive by their variety of colour than by their beauty of crystalline form. The mineral, which is a fluoride of calcium, containing fluorine 48·7, calcium 51·3, is found abundantly in nearly all our mining districts, especially in Cumberland and Derbyshire, Devon and Cornwall. Its chief uses are as a flux in certain metallurgical operations, and as a source of hydrofluoric acid.

By acting upon powdered fluor spar with sulphuric acid, hydrofluoric acid is liberated, and may be used to etch glass, which it attacks with great energy. A fine etching executed in this manner will be found in Case 56, p. 158.

The violet-blue variety of fluor known commonly as "Blue John," is used in the manufacture of tazze, as shown in this case, and of vases as exhibited in the Hall. The visitor will not overlook the magnificent vase No. 19, described at p. 63.

Being slightly soluble in water containing bi-carbonate of lime in solution, this mineral often disappears from the lodes in which it previously existed, leaving moulds of its form filled with other minerals, or coated by them. See such examples in Wall-case 34.

## CASE N.—QUARTZ.

Occurring under a greater variety of aspects than any other member of the mineral kingdom, the species *Quartz* necessarily claims a large amount of space, and hence it extends through this and the two succeeding cases. Pure quartz consists simply of silica, or oxide of silicon. The mineral crystallizes in forms belonging to

the rhombohedral system, and is sufficiently hard to scratch glass with facility.

*Rock crystal* is a pure transparent variety, frequently enclosing rutile, chlorite, various fluids, &c. Small brilliant crystals are often locally termed "diamonds;" such, for example, are the so-called *Cornish diamonds*, *Bristol diamonds*, &c. Under the name of "white stone," the mineral is occasionally employed in jewellery, those crystals being valued which contain slender prisms of rutile, or oxide of titanium, known to the jeweller as *flèches d'amour*, or *Love's arrows*. A more useful application of rock crystal is a formation of "pebble" lenses for spectacles. Thin fibres of asbestos (p. 137) penetrating the quartz give rise to the remarkable lustre of the *cat's-eye*, a mineral obtained chiefly from Ceylon.

*Smoky quartz* is a variety presenting a brownish tint, the term *morion* being applied when the colour becomes intense. The transparent brown and yellow crystals form the well-known Scotch stone called from its locality *cairn gorm*; whilst the bright yellow varieties are distinguished as *citrine* or *false topaz*. *Amethyst* is another form of crystallized quartz, usually presenting a purple colour, due probably to the presence of oxide of manganese or of iron. Amethysts of the finest quality are found in India, Ceylon, Persia, and Siberia. The pink colour of *rose quartz* is probably referable to a slight admixture of oxide of manganese.

#### CASE O.—QUARTZ, *continued*.

In this case the varieties of quartz are continued, and the series passes from the crystalline to the chalcedonic and jaspery forms of this Protean species. The eye will be arrested by the gold-spangled appearance of the *Aventurine*, which is probably due to the presence of minute scales of mica. The aventurine glass will be alluded to at p. 163. In the *ferruginous quartz*, or *Eisenkiesel*, the mineral is deeply coloured, and usually rendered opaque, by the presence of hydrous peroxide of iron. The specimens of *capped quartz* curiously show how a deposit of quartz has been thrown down upon a crystal of the same substance, with sufficient interruption to prevent perfect cohesion between the crystal and its cap; whilst the *pseudomorphs of quartz* suggest changes by which various minerals have impressed their specific forms upon the quartz, or have suffered removal, whilst the quartz has taken their place.

*Chalcedony* is a translucent variety of quartz, of a wax-like appearance, occurring chiefly in stalactitic forms. It has been regarded as a mixture of ordinary quartz with opal, or soluble silica. Many of our most beautiful siliceous minerals are simply coloured varieties of chalcedony; oxide of nickel, for example, producing the apple-green tint of the *chrysoprase*, while peroxide of iron gives rise to the bright red tint of *carnelian*, and the deep reddish brown colour of *sard*. These varieties are well represented in this and the following case.

#### CASE P.—QUARTZ, *continued*.

Some beautiful examples of chalcedonic and jaspery varieties of quartz are here grouped together. Regular alternations of light and dark coloured chalcedony are presented in the *onyx*, and on this depends its value for cameo work: when the layers consist of *sard juxtaposed* with strata of white chalcedony, the stone is called a *sardonyx*.

In the *moss agate* and *mocha stone* the dendritic or moss-like de-

lineations of an opaque brownish yellow or green colour are mostly due to oxide of manganese or of iron. The ordinary forms of *agate* are represented to a limited extent in this case, but are fully illustrated in the succeeding section.

Passing from the chalcedonies we find another group of siliceous minerals formed by the jaspery varieties of quartz. When the colours are in stripes it is called *ribbon jasper*, of which some Siberian specimens are here exhibited. In the *Egyptian jasper*, which occurs usually in the form of rolled pebbles, the brown colours are disposed in concentric zones. *Heliotrope*, or *blood-stone*, is a jasper of a deep green colour, interspersed with blood-red spots, found in Silesia, Iceland, and the Island of Rum, Scotland.

#### CASE $\phi$ .—AGATES.

Although a few examples of agate are placed in Case P., and a fine specimen stands at the southern end of the room No. 5 (p. 56), it has yet been considered desirable to devote this case specially to the display of agates, so as to fully illustrate the varieties presented by this beautiful stone, and to explain as far as possible their mode of occurrence. The beauty of the varied forms of *agate* depends chiefly on the alternation of different varieties of chalcedony and jasper. The agates are invariably found in the cavities of igneous rocks, akin to basalt, but generally associated with palæozoic strata. It is probable that the disengagement of gas or steam produced pear-shaped cavities in the igneous rock when in a fluid condition, and that these hollows, retained by the viscosity of the lava-like rock, have been since filled, partially or entirely, by silica and other substances deposited upon the walls of the cavities from solution in the water circulating through the rock. Many of the specimens in this case were selected by Professor Nöggerath, of Bonn, with the view of showing the inlets of infiltration through which the siliceous liquid is supposed to have gained access to the interior of the stone, and to illustrate other points in the genesis of agates, which are sufficiently explained by the labels accompanying the specimens. Reference has already been made (p. 56) to the chief localities of agates and to the agate-industry which is centred at Oberstein. It remains only to be said that most of the agates of commerce are coloured by artificial processes, such as boiling them in oil or syrup, and subsequently treating them with sulphuric acid; the oil or sugar is absorbed into the more porous layers, and then carbonized by the action of the acid; thus the artificial dark-coloured varieties are formed. By first boiling agates in solution of proto-sulphate of iron, and then exposing them to heat, by which peroxide of iron is formed, the red varieties are produced. For details of the process reference may be made to the article "Agate" in *Ure's Dictionary*, 7th ed., 1875.

#### CASE Q.—SILICA, *amorphous and hydrous*.

The quartz-family is here brought to a close by a few minerals, for the most part less attractive than those already noticed. Ordinary sandstone has been described in connexion with the building stones. (p. 36). The *flexible sandstone* here exhibited is a remarkable variety, the flexibility of which has been referred to the dissemination of small scales of mica through the mass. Several compact forms of silica are presented in the shape of *hornstone*, *chert*, and *flint*: in flint the silica appears to be partly in the soluble and partly in the insoluble state. Flints occur chiefly in the upper

chalk, in the form either of nodules or of regular bands: some characteristic specimens will be found among the rock-specimens in the upper gallery. Some of the applications of flint receive illustration here, and a collection of early flint implements is arranged in a table-case No. 15 on the opposite side of the room (p. 61).

In the mineral called *Opal*, which is generally regarded as specifically distinct from ordinary quartz, the silica exists in an amorphous, soluble, and usually hydrous condition, having solidified probably from a gelatinous state. The *noble* or *precious opal* has always been a much valued gem. The Orphic poem commends the opal, saying it has the delicate complexion of a lovely youth. This gem, Pliny says, the Indians so well imitated in glass that the counterfeit could hardly be detected. He also tells us that a senator named Nonius possessed an opal valued at twenty thousand sesterces; that Anthony proscribing him, he fled, saving, of his whole property, this ring only. The *precious opal* occurs in porphyry at Ozerwenitzza, near Kashau, in Hungary, and under similar conditions, in Honduras. The fine specimen from a recently discovered locality in Queensland will not fail to attract the eye; but the Australian opals have not yet been found applicable to the purposes of the jeweller. The *fire opal* is brought from Mexico, and the *common opal*, abundant in Hungary, is found also in Faröe, Iceland, the Giant's Causeway, and the Hebrides. *Hyalite*, or *Müller's glass*, is a colourless transparent opal; while *menilite* is an opaque brown opaline concretion occurring in the tertiary strata of Menil-montant, near Paris.

In this case are many examples, from Trinidad and other places, of the curious changes effected in wood by silicification; and in the first gallery will be found some larger specimens. The change has been so gradual that the woody structure is perfectly retained, and in the section of the palm trees in the gallery the arrangement of the cellular tissue is preserved.

#### CASE R.—ALUMINA; ANHYDROUS SILICATES.

The coarser forms of alumina, or oxide of aluminium, having been already described under the names of *emery* (p. 42) and *corundum* (p. 103), it remains to notice, in this place, only those fine transparent varieties which, from their excessive hardness and beauty of colour, are highly valued by the jeweller. These pure forms of alumina are almost exclusively brought from the east, chiefly from Ceylon, Pegu, and Ava, where they occur embedded in sands and gravels. The bright red varieties constitute the *oriental ruby*, so called to distinguish it from the totally distinct and much less valuable mineral, spinel, which is also known in commerce as "ruby." *Sapphire* is a name applied to the blue transparent crystals of corundum; Pliny's name of *asteria* being retained for the "star sapphires," or those varieties which exhibit a star of light when cut with a convex face. Other brightly coloured corundums pass in commerce as "oriental" gems; the green as *oriental emerald*, the yellow as *topaz*, and the purple as *amethyst*; but it must be remembered that these oriental stones differ essentially, both in chemical composition and in physical characters—colour only excepted—from the gems whose names they bear. The preparation and properties of metallic aluminium, the *base of alumina*, have been noticed at p. 75.

The large series of anhydrous silicates, occupying the remainder of this case and several of the following cases, embraces many minerals

of considerable value as precious stones. The double silicate of the allied earths alumina and glucina is known in its coarser varieties as *Beryl*, of which enormous six-sided crystals are found in the United States. The fine transparent green varieties are distinguished as *Emerald*, while those of paler tint pass under the name of *Aquamarine*. The rich colour of the emerald is due either to oxide of chromium, or to an organic colouring matter. The gem is chiefly obtained from the Mines of Muzo in New Granada, where it occurs crystallized in a black carbonaceous limestone. Specimens will be found showing its occurrence in the matrix, accompanied by some fossils from the limestone.

Closely related to the emerald in chemical composition is the mineral called *Euclase*, the excessive brittleness of which renders it useless for purposes of ornament. The earth glucina also occurs combined with alumina in the *Chrysoberyl* or *Cymophane*: certain varieties of this mineral, when cut *en cabochon*, exhibit a peculiar opalescence, whence the name *oriental cat's-eye*.

Among the small number of minerals which contain *zirconia*, the most important is the silicate called *Zircon*. The transparent coloured zircons are used as gems; the rich red varieties being distinguished as *Hyacinth* or *Jacynth*, and the less brightly coloured as *Jargoon*. The hyacinth occurs in the form of rolled crystals, chiefly in Ceylon and central France; whilst the coarse dull-coloured *Zirconite* forms a constituent of the peculiar zircon-syenite of Norway, and is also found in the miascite of the Urals.

Few minerals present greater complexity and variability of composition than the *Tourmaline*. Its crystals are remarkable for a want of symmetry between the opposite ends, and for acquiring electric properties on exposure to heat. The black tourmaline is commonly known as *Schorl*, and the pink as *Rubellite*: a striking variation of tint in the same crystal is well seen in the parti-coloured tourmalines from Elba.

#### CASE S.—ANHYDROUS SILICATES—continued.

Many of the silicates exhibited in this case are, like those in the last section, employed for purposes of ornament. The group of *Garnets* embraces a considerable number of minerals which are essentially double silicates, the varieties depending on the character of the bases. The deep-coloured *Almandine* or *precious garnet*, a silicate of alumina and protoxide of iron, is frequently cut *en cabochon*, when it is known as *Carbuncle*: and the *Essonite* or *cinnamon stone* is also used as a gem, being often mistaken for hyacinth. *Essonite* is a silicate of alumina and lime, thus having a composition similar to that of the Siberian *Grossularia* or *gooseberry garnet*. Another Russian garnet is the *Uvarowite*, a mineral having a bright emerald-green colour, and containing the silicates of lime, alumina, and sesquioxide of chromium. The species *Idocrase* or *vesuvian* has a composition identical with that of certain garnets, but crystallizes in forms totally distinct.

In the *Topaz*, to which we next pass, a silicate of alumina is associated with a silico-fluoride of aluminium. The topaz is found in the form of rolled pebbles, and in granitic rocks commonly associated with quartz, and not unfrequently with tin ore. The yellow and the white topazes, chiefly from Brazil, form valuable gems; and in many cases a pinkish tint is developed by exposure to heat. The topaz of the ancients appears to have been the stone which we now call *Chrysolite*: this is a silicate of magnesia of a dull green colour.

known also as *Peridot*, the name *Olivine* being applied to the less transparent varieties, commonly found in meteorites, and in basalt and other trap rocks. Examples of these varieties are exhibited.

The *Spinel*, or *spinnelle*, of which the bright red varieties are used as a gem under the name of *spinel ruby*, is not a silicate, but is a compound of alumina and magnesia, the latter being frequently replaced to a considerable extent by protoxide of iron.

#### CASE T.—ANHYDROUS SILICATES—continued.

The minerals in this case, although less attractive than those in the preceding sections, are nevertheless of the highest interest as rock-constituents. At the head of the series stands the family of *Felspars*, including a number of species, of which the best known is the potash-felspar, *Orthoclase*. The transparent orthoclase called *Adularia* is occasionally used for purposes of ornament under the name of *Moon stone*. *Microcline* and *Amazon stone* are two other varieties of orthoclase, the former noticeable for its beautiful opalescence, and the latter for its fine apple-green colour. An attractive specimen of Amazon stone, crystallized in cavities of a granitic rock, stands under a glass shade on an adjacent table-case. *Obsidian* or *volcanic glass*, is a vitreous form of felspathic lava, frequently produced by fusion of impure orthoclase. It is employed by many savage races for making cutting instruments, and was largely used in this way by the ancient Mexicans. The curious filamentous material from the Sandwich Islands, known as *Pelé's hair* is a capillary lava, similar to the hair-like forms of slag occasionally produced in the blast-furnace by the slag being caught by the blast from the twyer, and blown out into threads like spun glass. *Pelé's hair* should be compared with specimens of slag in case No. 4, p. 56. *Albite* and *Oligoclase* are closely-related soda-felspars, the soda being usually accompanied by lime in the latter species. The Norwegian *Sun stone* or *Avanturine-felspar* is a variety of oligoclase, notable for enclosing certain minute crystals from which light is brilliantly reflected. Orthoclase-felspar, commonly associated with either oligoclase or albite, forms an important constituent of granitic rocks (p. 24), whilst the soda-and-lime felspar *Labradorite* is characteristic of the group of basalts (p. 47). Attention need scarcely be directed to the beautiful play of colour exhibited by the polished slabs of labradorite.

#### CASE θ.—ANHYDROUS SILICATES—continued.

In this case the large and important series of anhydrous silicates is continued, and several interesting species are represented.

The well-known *lapis lazuli* appears to be a silicate of soda, lime, and alumina, with, probably, a sulphide of iron and sodium. It is found on the banks of the Indus in a crystalline limestone; and in limestone and granite it occurs in Persia, China, and Siberia. The richer varieties of lapis lazuli are employed in the manufacture of ornamental articles; and when subjected to careful powdering and washing, to free it from all foreign admixtures, it forms the *ultramarine* of the artist, which is so celebrated for its beauty and permanence. The rarity of the mineral, and the cost of preparation, render the true ultramarine of a very high price, 5*l.* 5*s.* per ounce.

An artificial ultramarine is prepared by mixing clay, carbonate of soda, and sulphur, and carefully heating the mixture; the result is a very fine blue colour, which is said to be equally permanent with the natural lapis lazuli, and which can be sold at 8*s.* the pound.

Examples of the genuine and of the artificial ultramarine stand side by side.

The members of the *Mica* family, of which several are here exhibited, differ from one another in crystalline form, optical characters, and chemical composition. They are important as constituents of granite, mica slate, and other rocks. A portion of an unusually large crystal of Canadian mica will be found in the lower part of Case No. 30.

*Jade* or *nephrite* is well known as a mineral which, in spite of its hardness, is largely worked into images and ornaments of various kinds by the Chinese; it is also found in Australia, New Zealand, and some parts of North-west America. It should be mentioned, however, that at least two distinct minerals have until recently been confounded under the general name of jade. The true jade is essentially a silicate of lime and magnesia, while the species *jadeite*, often mistaken for it, is a silicate of alumina and soda. The name *nephrite* is derived from *νεφρός* (*nephros*), *kidney*—it being used for diseases of that organ by some people. Some fine Chinese carvings in jade and jadeite are in Case 53.

Several beautiful crystallized minerals such as *Epidote* are fairly represented in this case, but as they have no general interest attaching to them, any notice would be out of place here.

#### CASE U.—ANHYDROUS SILICATES—continued.

Here the visitor will find a very instructive group of silicates embracing the different varieties of the closely-allied species *Augite* and *Hornblende*. It is notable that the augitic minerals are characteristic of lavas, basalts, and other igneous rocks, which contain the more basic feldspars; whilst the hornblendes occur in diorite, syenite, &c., usually in company with highly silicated feldspars and often with free quartz. There are exceptions however to such associations. The fibrous forms of hornblende and similar minerals are known as *Asbestos* (*inconsumable*), from their power of resisting the action of intense heat; hence asbestos cloth, woven from the delicate threads, may be exposed to fire without being consumed. The delicate fibres are distinguished as *mountain silk*, while the massive forms resulting from the interlacing of these fibres are called, according to their texture, *mountain leather*, *rock cork*, &c.

At this point we pass from the anhydrous to the hydrous silicates, commencing with the hydrous silico-borate of lime, called *Datholite*, a species, however, of only mineralogical interest. From this we turn to the well-known *Meerschäum* (*sea froth*), or *Ecume de mer*, so called in allusion to its lightness and white colour. This is a hydrous silicate of magnesia, found in Asia Minor, Turkey, Greece, Morocco, Spain, and Moravia.

#### CASE V.—HYDROUS SILICATES.

This case is entirely occupied with the two closely-related species *serpentine* and *steatite*, both hydrous silicates of magnesia.

Enough has already been said of serpentine as a rock, when describing the fine objects in the Hall (p. 29). Other examples of this ornamental stone are exhibited in the case before us, where also will be found specimens of *noble* or *precious serpentine*, a variety of oil-green colour, slightly translucent; of *chrysotile* and *picrolite*,

the one a fibrous and the other a columnar variety; of *marmolite* and *antigorite*, the former a foliated, and the latter a lamellar form of serpentine.

*Steatite* frequently occurs in association with serpentine, as in the Lizard District in Western Cornwall, where the ophitic rocks are traversed by veins of steatite. The mineral is remarkably unctuous to the touch, and is hence popularly termed *soapstone*; advantage is taken of this property in using powdered steatite for causing new gloves and boots to slip on readily; the variety employed for this purpose is generally known as *French chalk*. Soapstone is carved into pipes by certain South African tribes, and is also used by the Chinese for carving figures. It resists the action of heat and has been turned into gas burners and similar objects; at one time it was used in the manufacture of porcelain at the Worcester Works. When lamellar it is generally known as *Talc*, a name frequently applied improperly to mica; the two are however easily distinguished, the talc being flexible but not elastic, whilst the mica enjoys great elasticity.

#### CASE W.—HYDROUS SILICATES—*continued*.

It is the mineralogical student rather than the general visitor who will be interested in the minerals in this case. The *Chlorites* form a group of closely-allied minerals, comprising several species differing one from another in crystallographic and optical characters. The *Lemnian earth*, formerly valued in medicine, was esteemed sacred by the ancient Greeks, being mixed with goats' blood, and made into cakes, which were then stamped by the priests, whence it was called *sealed* or *sacred earth*. From the use of the *Agalmatolite* by the Chinese for carving figures it has received the names of *figure stone* and *pagodite*. Several distinct substances, however, are used for these Chinese carvings. The white powder labelled *Kaolinite* exhibits under the microscope beautiful little six-sided plates, and represents in a state of purity the hydrous silicate of alumina which in its impure forms constitutes our common *kaolin* or *china-clay* (see p. 141).

#### CASE X.—HYDROUS SILICATES—*continued*.

The *zeolitic minerals* occupying this and the following case are related by several characters in common. They are essentially hydrous silicates of alumina with an alkali or an alkaline earth; and are usually found in the cavities of amygdaloidal trap-rocks, a few however occurring also in metalliferous veins. Beautiful in their crystalline forms, and interesting in their chemical composition and mode of occurrence, the zeolites are highly attractive to the mineralogist, but as they receive no practical applications, any detailed notice in this place seems unnecessary. The principal species represented in this case are *Prehnite*, a hydrous silicate of alumina and lime, of which some fine examples are exhibited from the igneous rocks of the Dumbarton Hills; *analcime*, a hydrous silicate of alumina and soda, often containing also potash and lime; and *apophyllite*, a mineral differing from the true zeolites in that it contains no alumina, being in fact a hydrous silicate of lime and potash. Especially noteworthy are the fine Indian crystals of apophyllite brought to light during the cutting of the railway tunnels on the *stupendous inclines* ascending the Bhoire and Thul Ghauts (p. 104).

CASE Y.—HYDROUS SILICATES—*continued*.

Here the visitor will find a large number of beautiful zeolitic minerals, which it is unnecessary to describe in detail. The differences in chemical composition are sufficiently explained by the accompanying labels. Among the more noteworthy species attention may be called to *natrolite* in beautiful needle-like crystals; *chabasite*, in fine rhombohedral forms almost like cubes; *harmotome*, in milk-white twin-crystals, as though two individuals were crossing each other; and *stilbite* in crystals with broad cleavage planes exhibiting a pearly lustre. The salient characters of many of these species are sufficiently explained by their popular names, such as foliated zeolite, needle-stone, radiated zeolite, effervescing zeolite, &c.

## CASE Z.—PHOSPHATES OF ALUMINA, &amp;c.

A few minerals containing phosphate of alumina are grouped together in this, the last division of the horse-shoe case. *Wavellite* is a mineral occurring chiefly in small globular concretions, which when broken present a beautifully radiated structure; the species takes its name from Dr. Wavell, who discovered it at Barnstaple in Devon. *Childrenite* is a phosphate of alumina, iron, &c. found in a few localities only in Devon and Cornwall, and named after the late Mr. Children, of the British Museum. Passing over a few other rare species, the visitor will be attracted by the specimens of *Turquoise*. This mineral is a hydrous phosphate of alumina, containing copper; and when of fine colour is valued as an ornamental stone. The finest specimens are brought from Persia, others are supposed to come from Thibet; and some years ago discoveries were made in Arabia Petrea. From all these localities, especially from the last-named, specimens are exhibited. The mode of occurrence, and the turquoise separated from the matrix, are shown. The Arabian specimens were mostly presented by Major Macdonald, who thus describes the locality in which he found them:—"In the year 1849, during my travels in Arabia in search of antiquities, I was led to examine a very lofty range of mountains composed of iron sandstone, many days' journey in the desert; and whilst descending a mountain 6,000 feet high, by a deep and precipitate gorge, which in the winter time served to carry off the water, I found a bed of gravel, where I perceived a great many small blue objects mixed with the other stones; on collecting them I found they were turquoises of the finest colour and quality. On continuing my researches through the entire range of mountains, I discovered many valuable deposits of the same stones, some quite pure, like pebbles, and others in the matrix. Sometimes they are found in nodules varying in size from a pin's head to a hazel nut; and when in this formation they are usually of the finest quality and colour. \* \* \* \* Another formation is, where they appear in veins. They also occur in a soft yellow sandstone, enclosed in the centre, and of surpassing brilliancy."

In addition to the true *oriental turquoise* described above, the jeweller avails himself of a substance somewhat similar in general appearance, but known as *occidental turquoise*. This is the *odontolite* of mineralogists, a substance which appears to be nothing more than fossil ivory, bone, or tooth, coloured with phosphate of iron.

## CERAMIC AND VITREOUS SERIES.

*On the Eastern and Western sides of Stairs.*

POTTERY AND PORCELAIN. **Wall-cases** on the W. and E. sides of the embayments, and adjacent pedestal-cases; also table-cases in lower gallery.

A large collection illustrating the various branches of ceramic and vitreous manufactures, especially rich in illustrations of the history of British Pottery, is exhibited at the southern or Jermyn Street end of the Principal Floor, where it is entirely separated from the mineralogical and metallurgical collections. The ceramic and vitreous collection is arranged in a series of forty-four wall-cases distinguished by Roman numerals, in glass-cases resting on the cornice of the balustrade on each side of the staircase leading from the Hall, and in several pedestal-cases in the neighbouring area. The numbers and letters correspond with those on the objects exhibited, and with the references in the catalogue of pottery, of which a third edition has recently been published (1876).

It will be desirable to commence the description of the ceramic series by describing the raw materials used in the manufacture. Examples of these materials will be found in the lower compartment of Pedestal-case No. 57; and a valuable series of British clays, collected and presented by George Maw, Esq., is exhibited in the lower divisions of the several pedestal-cases occupying the two embayments.

CLAY, the plastic material upon which all ceramic manufacture depends, is essentially a hydrous silicate of alumina, its peculiar fictile properties being due to the presence of the combined water. The proximate constituents of pure clay are here represented by the *rock crystal* (A. 1), a pure form of *silica*; and by the *emery* (A. 2), an impure variety of *alumina*. The silicate of alumina formed by the union of these two compounds—*silica* and *alumina*—exists in combination with certain alkaline silicates in all the members of the felspar group; and it is by the decomposition of these felspathic minerals that our china clays are produced. In the common species of felspar called *orthoclase* (A. 3), a specimen of which is here placed as a representative of the family, the silicate of alumina is associated with a silicate of potash. When the felspar suffers decomposition the greater part of the alkaline silicate is removed in a soluble form, whilst the silicate of alumina, being left behind in a hydrated condition, forms the clay which we employ in our fictile manufactures. Specimens are exhibited of our principal pottery clays, of which the following are the more important:—

*Bovey Clay* (A. 15). This is obtained from Bovey Heathfield, Devonshire, and is derived from the decomposition of the felspars of the great granite ranges of Dartmoor; 59,789 tons were sent from the port of Teignmouth in 1874. The mode of raising it is extremely simple,—the gravel head is removed, and a large rectangular pit is sunk, which is supported by wood. The workmen cut out the clay in cubical lumps weighing about 30 lbs. each, and fling them from stage to stage by means of a pointed staff; it is then carried to the clay cellars, and when properly dried sent to the potters.

*Poole Clay* (A. 16), so called from being shipped at Poole, occurs in the Lower Bagshot beds of Dorsetshire, and contains numerous *vegetable remains*, principally parts of such plants as belong to a *sub-tropical climate*, like that of Africa along the shores of the

Mediterranean Sea. Examples of these plants will be found in the cases at the south end of the upper gallery, Nos. 52 and 56. 63,705 tons of this clay were exported in 1874 from the port of Poole.

*China Clay, Kaolin, or Cornish Clay* (A. 5 to A. 14).—About 1775 William Cookworthy, of Plymouth, discovered that the clays of Tregonning hill, in the parish of Breage, near Helstone, in Cornwall, were of the same character as specimens of Kaolin which he had seen, brought from Virginia. Associating himself in this discovery with Lord Camelford, Cookworthy worked the China clay on his Lordship's property in St. Stephen's, near St. Austell. He established the porcelain manufactory at Plymouth, which was eventually removed to Bristol, and thus laid the foundations of the great advance in porcelain manufacture in this country.

Kaolin or China clay is prepared chiefly in the neighbourhood of St. Austell, and St. Stephens, at St. Day, Towednack and Tregoning Hill, in Cornwall; and at Lee Moor, and at Meavy in Devonshire. The decomposed granite rock is broken out, and is commonly exposed on an inclined plane to the action of a fall of water, which washes it down to a trench, whence it is conducted to catch pits. The quartz, schorl, mica, and other minerals present are chiefly retained in the first pit, and as the water charged with the clay flows onward it deposits the grosser particles, and eventually the pure and fine clay is deposited in tanks prepared to receive it. These tanks are about 9 or 12 inches deep, and when filled with clay the water is turned in another direction, and the mass allowed to consolidate. The clay is then run into a roofed building, beneath the floor of which hot air circulates freely. Thus the clay is dried perfectly. It is then cut into oblong lumps and having been scraped to remove dust from the outside, it is sent to the potteries. In Devonshire and Cornwall artificial heat is applied, but the clay was formerly dried at the natural temperature.

In 1874, 150,500 tons of China clay were exported from Cornwall and 33,309 tons from Devonshire.

The China clay is now used extensively in our paper manufactories, it is finding a new application in the preparation of the figured papers for walls, and it is used extensively in all our bleaching establishments.

*CHINA STONE* (A. 22 to A. 25).—This is generally regarded as the product of the granite rock which furnishes the Kaolin, but in a less advanced state of decomposition—the felspar still retaining much of its silicate of potash or soda, associated with the quartz and scales of a greenish-yellow talcose substance. Of China stone there were sent to the potteries from Cornwall in 1874, 42,500 tons.

*FLINTS*, as obtained from the chalk districts (A. 26), and in a prepared state, calcined, crushed, and ground (A. 27 to A. 29). It is said that the introduction of flints into the manufacture of pottery was by Mr. Astbury, a Staffordshire potter, who was led to make experiments on their use from the following circumstance:—

In 1720, riding to London on business, as was then a common practice, he found, on reaching Dunstable, that his horse's eyes were disordered: he consulted the ostler at the inn, who placed a piece of flint into the fire, heated it to redness, and after throwing it into water, reduced it to powder, a little of which powder he blew into the horse's eyes. Astbury, observing the white character of the burnt flints, sent some to Shelton, where he had them burnt and powdered, and mixing the powder with pipe-clay, he first washed his ware with it, but ultimately introduced the flints into the body.

In a table-case in the gallery immediately above there are some

samples of raw materials used in some of the continental porcelain works. The materials in boxes are those employed at the French porcelain manufactory of Sèvres; and those in bottles are examples of the materials used in the porcelain works at Berlin.

**POTTERY MANUFACTURE.**—As space will not allow of a detailed description of the various processes of pottery manufacture, the following outline must suffice. The prepared materials, reduced to a finely divided state and suspended in water, are mixed in due proportions; and the fluid mixture, or 'slip,' brought to a pasty consistency by evaporation in the 'slip kiln.' The paste thus prepared is shaped, either by moulding, or more usually by 'throwing' on the potter's wheel; and the form, if necessary, is afterwards perfected by turning in the lathe. When handles or other appendages are to be added, they are attached at this stage by means of slip. After slowly drying, the ware is packed in fire-clay boxes, called 'seggars,' and baked or 'fired' by exposure in the 'biscuit kiln.' The porous baked ware, known in this state as 'biscuit,' is then ornamented by painting or printing; and having been dipped into the glaze suspended in water, is finally baked in the 'gloss kiln,' where by the vitrification of the glaze the pottery becomes covered with a thin coating of transparent and impermeable glass. The various stages in the manufacture are illustrated by specimens in the lower compartment of Pedestal-case, No. 57.

The arborescent patterns upon (B. 10 to B. 12) are produced by having first, an evenly-spread coating of 'dip' over the ware, and then dropping upon it another 'dip' compound, having a greater density than the first: by holding the piece so that the heavier colour can descend amid the moist, first-spread 'dip,' it disseminates its particles in an arborescent manner.

Several designs will be found in this case illustrating the transfer of engravings to pottery, a process now constantly employed in its ornamentation. Being recently printed on a thin paper, the design is applied to the surface of the absorptive ware, and being carefully rubbed close, the article is dipped into water, the wetted paper is then removed by rubbing, and the design is fixed on the absorbent clay, which is then glazed and fired in the ordinary way. An earthenware slab (G. 524, Wall-case XXXVII., E. side), in the form of a framed picture, shows a transfer in colours of Mulready's "Village Schoolmaster."

It is ever interesting to trace the progress of any special industry bearing upon an important branch of modern manufacture. The Museum of Practical Geology was intended to show how mineral products have been rendered useful; and as our ceramic manufactures form an important feature, some history of their progress was deemed desirable. To read the series aright, it will be necessary to examine this art-manufacture in some of the most ancient of the preserved examples.

**ASSYRIAN AND BABYLONIAN BRICKS.** Case 63. (C. 23 to C. 28).—The glazes have been examined in this establishment, and they are found to be silicates of soda, or soda glass, coloured opaque white with oxide of tin (*Putty powder*), yellow with antimoniate of lead (*Naples yellow*), and blue with silicate of copper. The blue colour from copper was previously known, but the use of lead, antimony, and tin, in glazes or enamels, has to be carried many centuries further back than has been usually supposed.

**EGYPTIAN SEPULCHRAL FIGURES, &c.** Case 63. (C. 1 to C. 22).—Many of these figures are of pottery, or rather of a frit formed of grains

of sand cemented by some vitreous material; but some of the figures and scarabæi are found to be carved out of a steatitic mineral. These have been dipped in a cupriferous glaze and then fired, the steatite resisting the heat required to fuse the glaze.

Those examples of the times of the Pharaohs serve to show the early condition of the potter's art: from them we learn that the Egyptians had found that steatitic minerals might be advantageously employed in the place of the ceramic bodies.

INDIAN ENAMEL. Case 63. (C. 29.)—In this specimen the frits are enamelled with different-coloured glasses and enamel frits, then cut so as to form a design in mosaic, when embedded on a wall of *chunam* or plaster. These enamelled frits have been used in India from the 13th century. This example is from the tombs of the Kootub dynasty, Golconda.

ANCIENT GREEK AND ETRUSCAN POTTERY. Case 67. (C. 30 to C. 51) —This case is placed on the bridge which spans the staircase leading from the Hall to the Principal Floor. In the Greek vases may be studied, in addition to the character of the clay bodies, the style of ornamentation, the glazes, and especially the forms, many of which are very beautiful. In nearly all these vases the body is of a reddish clay, and the white and other colours employed in the ornament are coloured clays or *engobes*, painted on the vases after sketches of the designs were executed on them.

ROMAN POTTERY found in Britain. Case 64. (E. 1 to E. 196.)—The Roman pottery is of three descriptions. *The Upchurch ware*, which is of a fine and hard texture and of a blue-black colour, was baked in "smother kilns," where it was acted on by the smoke of vegetable substances. The forms are very varied and the patterns much diversified. In the creeks of the Upchurch marshes at the mouth of the Medway may be detected, at a depth of about three feet from the present surface soil, a stratum, often a foot thick, of broken pottery.

This deposit of pottery has been traced at intervals through an extent of six or seven miles in length and two or three in breadth. Mr. Wright says, "There can indeed be no doubt that the Upchurch marshes furnished a great portion of the commoner pottery used in Roman Britain." A fine collection of this Upchurch pottery is arranged in the lower compartments of the adjacent Cases 68 and 69.

*The Castor or Durobrivian pottery* was of a superior quality, and adorned with more elegance than that of the Upchurch marshes. Mr. Artis has explained, in his *Durobrive of Antoninus*, the mode of manufacture. The third variety is the *Samian Ware*, so called from being similar to the earthenware made from the red clay of Samos. Of this a very large quantity has been found in England: whether the Samian ware was ever manufactured in Britain has given rise to much discussion. That it must have been of much value is proved by finding bowls and pateræ of this red ware, which have been broken by their Roman possessors, and subsequently mended by means of lead rivets, in the same manner as earthenware and china are now mended by metallic wires or bands; several examples of such repaired pieces are in the collection. The common Samian ware of Britain is of delicate texture and of a fine red colour. Many of the specimens exhibited were discovered during the progress of improvements in the city of London: Cannon Street, Foster Lane, Queen Street, and Lad Lane have yielded a large number of these relics.

ROMAN POTTERS' KILNS AND TOOLS discovered in *Britain*. Case 64. (E. 75 and E. 76).—The kilns of which these are models were found at Normanton Field, Castor, near Peterborough. A great number of such kilns were discovered by Mr. Artis, and the following quotation from his description of them shows the extent to which earthenware manufacture was carried on in this country by the Romans.

"I have now traced these potteries to an extent of *upwards of 20 miles*. They are principally confined to the gravel beds on the banks of the Nen and its tributary streams; the clay used at some of them appears to have been collected at some little distance from the works. The kilns are all constructed on the same principle. A circular hole was dug, from three to four feet deep and four in diameter, and walled round to the height of two feet. A furnace, one third of the diameter of the kiln in length, communicated with the side. In the centre of the circle so formed was an oval pedestal the height of the sides, with the end pointing to the furnace mouth; upon this pedestal and side wall the floor of the kiln rests; it is formed of perforated angular bricks meeting at one point in the centre. The furnace is arched with bricks moulded for the purpose. The side of the kiln is constructed with curved bricks set edgeways in a thick slip (or liquid) of the same material to the height of two feet."

The bone and ivory tools, and the bronze instruments—all found at Castor—were used, there can be but little doubt, for producing patterns on the clays. A large fragment of a cake of glass or frit (E. 86) was also found in this pottery. This has been analyzed in the establishment, and found to be a silicate of soda and lime, similar indeed to much of the Roman glass.

ROMAN POTTERY, *from the Rhine*. Case 64.—As examples, important for comparison with the pottery found in Roman Britain, these are of much interest. They were manufactured on the banks of the Rhine, where, in several localities, Roman pottery kilns have been found. It is not improbable that the red lustrous ware of Rhenish manufacture was introduced into Britain; it is certain that large quantities of pottery of a precisely similar character have been discovered in this country.

MEDIEVAL POTTERY. Case 63.—Under this general head are grouped many articles dissimilar in character, and widely separated in date. These examples were collected for the purpose of exhibiting the progress of glazing. The tiles (C. 52 to C. 69) which have been found in various parts of England, are coated with a lead glaze; whilst those of the Moorish palace of the Alhambra and the Alcazar show the use of a stanniferous enamel. Moorish tiles were probably introduced into Italy in 1115, when Majorca was taken by the Pisans, and they were for a long period employed for ornamental purposes in churches. Luca della Robbia, celebrated for his terra cotta figures and bas-reliefs covered with a stanniferous glaze, also made enamelled tiles which he introduced into the church at Pisa about 1415-20.

MAJOLICA OR RAFFAELLE WARE. Case 63. (C. 90 to C. 100).—The Moorish ware was first introduced into Majorca, and from thence it spread over Italy, under the name derived from this island, "*Majolica*." It has been called *Raffaelle ware* from the fact that some of the decoration has been copied from the designs of that painter; *many of them* are by artists of his school, but it is believed that *Raffaelle himself* never painted on this ware, although a letter is *attributed to him* in which he informs the Duchess of Urbino that

the designs are ready which she had desired for porcelain for her sideboard. This ware was most extensively manufactured from 1540 to 1560. It was especially patronized by the Dukes of Urbino, whose arms are on the rim of one of the specimens. The manufacture greatly declined after 1574. The chief point to be observed in the Majolica is, that the body or paste was first fired, and then by immersion covered by a composition of oxide of lead, oxide of tin, and white earth, the proportion of tin being increased as the enamel was required to be white and hard.

**PALISSY WARE.** Case 63.—Palissy of Saintes was in every respect an extraordinary man. He was born in 1509, at Chapelle Biron, a poor hamlet near the small town of Biron in Perigord, but politically situated in the diocese of Agen. He was educated as a glass painter. He writes of himself in *L'Art de Terre*, "I for a long time practised glass painting until I was assured that I could earn bread by labour on earth." Some accidental circumstance directed his attention to pottery, and he was seized with an earnest desire to discover an enamel for a clay body which would equal anything which had been produced. Not knowing what had been done by others, he, with the utmost enthusiasm, proceeded in his inquiry. Bernard Palissy, speaking of his experiments, says, "Having blundered several times at great expense, and through much labour, I was every day pounding and grinding new materials and constructing new furnaces, which cost much money, and consumed my wood and my time." Again, he says, "I fooled away several years with sorrow and sighs, lessening the bread of my children, and weighed down by domestic cares." Eventually success crowned his endeavours, and the works of Palissy the Potter became famous. None of the genuine ware of Palissy is at present in the collection, but the copy, C. 101, sufficiently shows the character of the ware, in which its author,—a devout lover of nature,—executed in relief, reptiles, fish, plants, and even the fossil shells of the environs of Paris, with the most marked attention to the minutest peculiarities.

**DELFT DISH.** (C. 103.) Case 63.; also specimens in wall-cases on western side, bottom shelves. The manufacture of the famous Delft ware was established about the commencement of the seventeenth century, and for a long period was much esteemed in this country. The composition of four of the most important of the wares just named proves to be very similar: they all agree too in being coated with glazes containing tin. Brongniart gives the result of his analyses as follows:—

—	Silica.	Alumina.	Lime.	Mag- nesia.	Oxide of Iron.	Carbonic Acid, &c.
Luca della Robbia -	49·65	15·50	22·40	0·17	3·70	8·58
Majolica - - -	48·00	17·50	20·12	1·17	3·75	9·46
Delft - - - -	49·07	16·19	18·01	0·82	2·82	13·09
Palissy - - -	67·50	28·51	1·52	—	2·05	—

The marked difference between the Palissy and the other wares is the increased quantity of silica, and the exceedingly small proportion of lime.

**CHINESE PORCELAIN.** Case 63. (C. 104 to C. 116.)—These illustrations serve to show us in what respects we have still to learn

something of these celebrated oriental potters. Many of the peculiarities presented in their works have not yet been successfully imitated in Europe; the colours given to the jar (C. 107) furnish one example of this; here a felspar glaze is employed, and the blue silicate of copper and of an alkali has been partially reduced, so that a portion remains of a purple colour, from the dissemination of suboxide of copper amid the silicates. *Cracklin China* (C. 110 and C. 111) is produced by covering the white porcelain body with a thick opaque enamel which, after firing, "crazes" or splits in various directions.

According to M. Stanislas Julien the manufacture of porcelain was commenced in the country of Sin-p'ing sometime between B.C. 185 and A.D. 87. It is now largely manufactured at several localities. Davis informs us that there is a large manufactory at King-te-chin, and another at Chau-king-foo, west of Canton; it is said that at the former place there are nearly 3,000 kilns.

The Chinese potters employ *Kaolin* (from *Kaou-ling*—lofty ridge) and *pe-tun-tse*. It is generally said that the Kaolin is similar to the Cornish China clay, and the pe-tun-tse, in all probability, to the China stone of the same district. *Hua-she* (slippery stone), steatite, or soapstone is also used by the Chinese. Laurent and Malaguti give analyses of the Chinese ware:—

—	Silica.	Alumina.	Potash.	Lime.	Protoxide of Iron.	Magnesia.
Body of a white vase - -	70.5	20.7	6.0	0.5	0.8	.01
Body of a greenish white plate -	63.5	28.5	5.0	0.6	0.8	Trace.

The Portuguese introduced Chinese porcelain into Europe about the year 1520, but the earliest mention of China ware in England is said to be in 1586.

EUROPEAN PORCELAIN.—The introduction of Chinese porcelain into Europe produced a strong desire to imitate it, and it is said that a soft paste was manufactured at Florence as early as 1580. No real advance, however, towards making a porcelain of hard paste similar to the oriental was made until Böttcher's discoveries in the 18th century.

Böttcher first worked at Dresden with a brown clay, found near Meissen, and produced a red ware; and in 1709 he made white porcelain. Augustus II., Elector of Saxony and King of Poland, established porcelain works at Meissen, and Böttcher was appointed director in 1710. In 1715 he succeeded in making fine and excellent porcelain. This manufactory has continued to the present day, producing that superior porcelain commonly known as Dresden China. There is a curious story connected with this manufacture. John Schnorr, an ironmaster, riding near Aue, observed that a soft white earth adhered to his horse's feet; considering that this earth might be used as a substitute for wheat-flour as hair powder, he carried some away with him, and it was subsequently sold in large quantities for this purpose at Dresden, being known as *Schnorr'sche weisse Erde* (Schnorr's white earth). Böttcher finding his hair powder was heavier than usual, was induced to examine it, and this led to the discovery of the use of kaolin in porcelain at Meissen, where its employment was long kept a profound secret. The establishment at

the Albrechtsburg was a complete fortress for the confinement of the people employed, and "Be secret until death" was placed on the walls of the workshops. The specimen of Böttcher ware exhibited in the first gallery was produced about the year 1796.

From Meissen, however, the secret of the manufacture of porcelain spread, and Berlin, Munich, and St. Petersburg, about the middle of the 18th century, boasted of their potteries. The Sèvres works were established at St. Cloud, before 1695, but it was not until about 1769 that the use of kaolin was introduced, it having been then recently discovered at St. Yrieix, near Limoges.

In England a kind of porcelain appears to have been made at Fulham by John Dwight as far back as 1671. The earliest works of any importance, however, were those of Bow and Chelsea. The Bow factory appears to have been established about 1730, but reference to this will again be made when describing the collection of early English porcelain (p. 151).

*COLOURS used on Pottery and Porcelain. Table-case No. 55.*—The colouring materials employed in painting pottery always consist of a mineral colouring agent, usually a metallic oxide, associated with some easily fusible substance, such as an alkaline silicate. On exposure to heat this flux fuses to a vitreous mass, which becomes coloured by the metallic oxide, and hence all pottery-pigments may be simply regarded as coloured glasses. Those colours which are neither volatilized nor decomposed by heat are applied to the ware when in the state of "biscuit," whilst the less stable colours which would be injured during the baking are not applied until after glazing, the colour being fused by subsequent exposure to a comparatively gentle heat in a muffle.

In this case will be found an interesting series of porcelain colours from the works of Sèvres and Berlin; a highly illustrative series of British pottery colours, prepared and presented by Messrs. Emery, of Cobridge; a large number of specimens presented by Messrs. Minton; and several examples of enamel-colours from Messrs. Maw & Co.

The process of transfer-printing on pottery has been explained at p. 142. The blue colour so general on common earthenware is produced by the oxide of cobalt. Examples of printing will be found distributed everywhere through the ceramic collection.

It will now be desirable to describe the collection illustrating the history of the potters' art in this country. This collection occupies the entire series of wall-cases in this portion of the building, and commences with Case I., on the eastern side. The upper shelves of Cases I. to V. are occupied by a collection of mediæval pottery, found mostly in the city of London. From this we pass to the early productions of Staffordshire.

#### STAFFORDSHIRE POTTERY AND PORCELAIN. *Wall-cases on Eastern Side.*

"*The Potteries*" have been celebrated in this country as a locality in which, from a very early period, earthenware was manufactured. We are not enabled to connect the early Staffordshire ware with the Romano-British by any existing links; the earliest manufacture of which we have any exact account being that of a coarse ware in 1500. The *butter-pot* (G. 1, 2, 3) was such an important object of the Staffordshire manufacture as to be the subject of an Act of Parliament in 1661. Plott, who wrote in 1686, says, "The butter they buy by the pot, of a long cylindrical shape, made at Burslem, in this county, of a certain size, so as not to weigh above six pounds at most, and yet to contain at least 14 pounds of butter, according

to an Act of Parliament made about 14 or 16 years ago for regulating the abuses of this trade." Dr. Shaw remarks in 1829, "that the common people of the district, at the present day, call Irish tub butter *pot-butter*." Pot-butter is still a common term in the western counties, and frugal housewives talk of "potting" butter for the winter supply in the spring and early summer. The drinking vessel in the form of a bear (G. 4) is so formed that it could not be set down until it is emptied; hence the adage "'ware the bear." The *tygs* (G. 7 to G. 17) were the many-handled drinking cups of those times; each person drinking used a separate handle, and hence brought their mouths to different parts of the rim. The candlestick (G. 23) has a date upon it 1649, and the large dish (G. 24), ornamented in the centre with a crowned lion, bears the maker's name, THOMAS TORT. These and sundry mugs, porringers, &c. mark the peculiarities of the manufacture of Staffordshire before 1680, up to which time the clays employed appear to have been all obtained from the coal measures of the neighbourhood.

On the revolution of 1688 the Elers brothers came from Nuremberg, and at their works, which they established near Burslem, they made the red ware exhibited (G. 56 to G. 68), in imitation of the Japanese pottery. Many strange and some improbable stories are related of these potters and their jealous rivals; but certain it is that the Elers, from competition and annoyances, were compelled to abandon their works in Staffordshire somewhere about 1710. Better clays were introduced, and the use of flint in pottery was discovered; thus the *cream-coloured ware* and the *white ware* were gradually manufactured (G. 87 to G. 186). It will be observed that the forms are more perfect than they were; this may be referred to the introduction of plaster of Paris moulds, which were adopted from the porcelain manufactories of France. The ornamentation is altogether of an improved description, and it is evident that great attention was now paid to this increasing branch of trade. The glaze on this ware was produced by throwing common salt into the kiln.

Early examples of the transfer of engraving upon the glaze will be found.

In addition to the white and drab salt-glazed ware, this part of the collection contains specimens of the peculiar *agate ware* (G. 69 to 78) and *tortoise-shell ware* (G. 79 to 86) manufactured in Staffordshire up to the latter end of last century.

*Wedgwood's Ware.* (G. 219 to 354 in upper shelves of Wall-cases VI. to X.).—This collection exhibits the remarkable improvements which were at once made by a man who united great energy of character with a fine appreciation of the beautiful. Wedgwood was born in 1730, and as a boy worked in a small pottery belonging to his father, as a thrower. In 1759 he commenced for himself in an humble way, manufacturing small ornamental articles. He very much improved the *Cream Ware* of the time, first made by Mr. Wood, and having introduced it to Queen Charlotte, he received permission to call his manufacture *Queen's Ware*. This ware and his knife-handles must be regarded as the foundation of Wedgwood's fame and fortune. Associated in partnership with Mr. Bentley of London, Wedgwood succeeded in securing the assistance of artists, such as Flaxman, and the support of the patrons of art. From this time may be dated those beautiful productions which are so associated with the name of Wedgwood—vases, cameos, medallions, and the like, which have not been excelled by any manufacturer since his time. A fair selection of these will be found in the collection, showing the great variety of manufactures in which he engaged.

As a fine example of Wedgwood's productions, a copy of a large Greek vase in the British Museum collection should be examined. This, the largest work executed by Wedgwood, was presented to the Museum by the late Mr. Apsley Pellatt; the original was formerly in Sir W. Hamilton's collection. It belongs to the latest period of vase-painting, known as the style of the *Basilicata*, and is supposed not to be earlier than 200 B.C. This noble example is mounted on a pedestal near Wall-case I.

A fine collection of Wedgwood's cameos has recently been arranged in two glass Cases No. 58, placed on each side of the pillar opposite to Wall-case VIII. The collection comprises 214 specimens, showing the character of the black Egyptian ware, or basalt, and of the famous blue and white jasper ware, a material which lends itself with admirable effect to the production of cameo-work. Further information respecting Wedgwood ware will be found in Miss Meteyard's *Life of Josiah Wedgwood and Handbook of Wedgwood Ware*; and in Mr. Jewitt's *The Wedgwoods*. M. L. Arnoux, in his Lecture on Ceramic Manufactures, says:—"It is not only that nature, when she gave the English people commercial and industrial genius, gave them also a soil richly supplied with the best materials for this manufacture, but it is to the exertions of some men of genius that England is indebted for this result; and I think it only just to consider Wedgwood as the man who has given to the English ceramic art the powerful impulse it has preserved up to the present time."

Whilst the upper part of the Wall-cases numbered VI. to X. is devoted to illustrations of Wedgwood's ware, the lower shelves of these cases are occupied with examples of old Staffordshire pottery, showing the character of the manufacture as carried on by his contemporaries and successors. The series commences with some of the old ware of Ralph and Enoch Wood, and passes on to the productions of Mayer, Neale, Turner, Shorthose, Adams, Wilson, Mason, and other well-known Staffordshire potters. The Spode ware may be regarded as a connecting-link between the wares in this series and those of Copeland and Garrett, which take a prominent place in the collection of modern Staffordshire products exhibited in the wall-cases on the opposite or western side of the room, to which we now cross.

MODERN STAFFORDSHIRE POTTERY AND PORCELAIN. (Wall-cases XXXV. to XXXIX., western side; and Pedestal-case No. 62).—The present productions of the Staffordshire potteries are evidences of the successful attempts which are now making to equal the best works of other countries. Here will be found fine examples of the works of Messrs. Copeland and Garrett, Messrs. Minton, and other leading potters. Modern English earthenware, which has of late years greatly improved, requires no description in these pages. The English porcelain is what is called *soft porcelain*, and is composed of three constituents, *Kaolin* and *Cornish China stone*, with *bone ashes*. *Soft porcelain* differs from *hard* by the presence of phosphate of lime, and by containing but a small quantity of alumina and a large proportion of vitrified materials. The soft porcelain cannot resist the sudden changes of temperature; and generally, when you see a very transparent pottery, you may be certain it will not stand the fire; there is only one material which gives that property—it is the alumina, and that is perfectly opaque. (*Arnoux*.) Soft porcelain requires two firings, one for the biscuit, and the second for the glaze; the last, however, at a much lower heat.

Case 62 contains examples of the finest productions of our Ceramic manufactures at the time of the Great Exhibition of 1851.

*Parian, Carrara, or Statuary Porcelain.* Case 62.—By these names a vitrified body which is intended to imitate statuary marble is distinguished. It has not been introduced many years, and the result obtained depends on the employment of a soft felspar instead of the Cornish stone. The fabrication of Parian figures requires more dexterity than any other branch of porcelain manufacture. The proper mixture of prepared clay and felspar being made, it is mixed to the consistence of cream, technically called "slip," and in this state poured into moulds of plaster of Paris, which absorb the water from the clay. These figures are cast in a great number of separate pieces; as many as 50 moulds are required for some pieces, and much experience and a knowledge of the human figure are required to unite them into one. The figure being formed from the cast pieces still requires much attention. In the processes of drying and firing the model shrinks no less than one quarter, and as the contraction is in all directions, and is determined by the thickness of the body, various allowances have to be made. Again, being made of a fusible material, these would lose their shape, and fall, if not supported all round with props of the same material. The firing itself requires great attention, as on it depends the colour of the figure—the colour being due to a silicate of the peroxide of iron, which produces the yellowish white which is so agreeable in these figures.

The specimens exhibited will sufficiently show the applicability of this material to the reproduction of the finest works of art. Its capabilities are great—but as yet, owing to the difficulties of manufacture, it has not been possible to render these porcelain figures so cheaply as could be desired. In the education of the people, the advantages to be derived from rendering them familiar with the most beautiful objects are so evident, that no effort should be spared to improve this manufacture, and to place the results within the reach of every one.

*Terra Cotta.* Case 62. *Galatea and other figures in the Lower Hall.*

This term signifies literally *baked earth*, and it may therefore be extended to numerous articles of pottery.

The revival of the manufacture of terra cotta in England belongs to Josiah Wedgwood, who in 1770 manufactured it largely in Staffordshire. In 1790 a manufacture of terra cotta was carried on in Lambeth by a lady of the name of Coade, and until within the last few years by Coade and Sealey, who made large articles, such as statues, vases, &c., and architectural decorations, in the production of which such artists as Bacon, Rossi, and Parrietta were engaged. Rossi manufactured the capitals and statues of St. Pancras Church of this material; and the frieze of the Opera House in the Haymarket is from the manufactory of Mr. Bubb.

In executing a work in terra cotta the original work is first modelled in clay, and a plaster of Paris mould is then taken from this. Sheets of clay are beaten on a bench to the consistency of painter's putty, and pressed by the hands into these moulds. After the clay has been allowed to dry a little in the plaster mould, the latter is removed and the clay *moulded* article is exhibited. A skilful workman or artist goes over this, and removes the seams left by the mould where the sections come together, and repairs any defects which appear on the surface of the impression. The work is then left to dry gradually, and if large, props are properly applied; when sufficiently dry for baking, it is conveyed to a kiln,

and the fire being gradually raised, it is baked, and the article becomes *Terra cotta*. The heat should be of sufficient intensity to blend and partly vitrify the materials of which the mass is composed, without melting or distorting the ware. As soon as this temperature is obtained the firing is stopped, and all apertures closed to prevent the admission of air. When the kiln has cooled, the finished terra cottas are withdrawn. The example of Galatea will convey an idea of the size to which such works can be carried. The figure of Australia, modelled by John Bell, and manufactured by Mr. Blashfield, which is at the Crystal Palace, Sydenham, is of the height of nine feet—this was burnt in one piece. Several other figures equally colossal have been manufactured at the Millwall terra cotta works, and at the establishment of Mr. Minton, Stoke-upon-Trent. (See *History and Manufacture of Ancient and Modern Terra Cotta*, by J. M. Blashfield.)

FRIEZES, ENAMELLED BRICKS, TILES, &c. *Specimens under Balustrade on Eastern Side and under Windows.*

The friezes, of which there are four, are in imitation of the Luca della Robbia ware; the other examples of ornamental earthenware are intended to show its applicability to the decoration of rooms and other architectural purposes.

The hollow bricks are thought to combine the advantages of strength and lightness, and, from the free circulation of air through the perforations, to ensure perfect dryness to the walls. These are manufactured by Prosser's process (p. 46); they are then painted and enamelled, so that the interior decoration of an edifice is produced as the wall is built.

Some excellent examples of modern enamelled ware, applicable to ornamental architecture, manufactured and presented by Messrs. Maw and Co., will be found in the upper part of Wall-cases XXXIX. to XLIV.

ENGLISH PORCELAIN. *Wall-cases XI. to XXXIV. under Windows at Southern End.*

BOW PORCELAIN. *Cases XI., XII.*—The Bow porcelain works were probably established about the year 1730, and in 1775 or 1776 they were sold to Mr. Duesbury of Derby.

A writing on the cover of a box in the British Museum, containing a porcelain bowl, informs us that "the above manufactory was carried on many years under the firm of Messrs. Crowther and Weatherby, whose names were known almost over the world; they employed about 300 persons; about 90 painters (of whom I was one), and about 200 throwers, turners, &c., were employed under one roof." The writer, who was the enameller of the bowl, signs his name, T. Craft, 1790. Of late years our knowledge of the old Bow porcelain has considerably increased, principally through excavations conducted on the site of the works by Messrs. Bell and Black in 1868. Some of the fragmentary pieces then found are here exhibited, together with a number of typical specimens which will serve to give an excellent idea of the character of the productions at this factory.

CHELSEA PORCELAIN. *Cases XIII., XIV.*—Under the auspices of the Duke of Buckingham, in 1676, some Venetians established at Chelsea a glass-manufactory. As the Venetians well understood the manufacture of opaque glass (see the Venetian Case, No. 65), the transition from this manufacture to that of porcelain was easy. It is said

that the Elers (*Elers ware*, p. 148), when they left Staffordshire in 1710, joined these works, and greatly improved the ware and the designs. The Chelsea potters are stated to have obtained Kaolin from China, but this is highly improbable, as they obtained sand from the Isle of Wight, and probably procured from Dorsetshire the clays then well known. George II. especially encouraged the Chelsea works, procuring models, workmen, and materials from Saxony and Brunswick for them. The greatest excellence was achieved, and the works were in the height of success between 1750 and 1765. A set of Chelsea porcelain is stated by Horace Walpole to have been presented by the King and Queen to the Duke of Mecklenburgh, which cost 1,200*l.* (*Marryat's History of Pottery and Porcelain.*)

These works were discontinued about 1765, and the models were purchased for the manufactory at Derby.

**DERBY PORCELAIN.** *Cases XV. to XIX.*—These porcelain works were founded by Mr. William Duesbury in 1751. Not only did the Bow and Chelsea moulds find their way to Derby at the closing of those works, but many of the workmen and artists were attracted thither. Derby may therefore be regarded as having united in another locality the porcelain works of Bow and Chelsea. Boswell, recording Dr. Johnson's visit to the Derby works, says that the great doctor admired the beauty of the porcelain, but objected to the price, observing "that he could have vessels of silver of the same size as cheap as what here were made of porcelain." The Derby porcelain works continued until 1848, when they were finally closed, a minor manufactory, however, still remaining. The typical productions of the works are fairly represented in this series, and full information on the factory and its products will be found in Mr. Haslem's *History of the Derby Works*.

**PLYMOUTH PORCELAIN.** *Cases XX., XXI.*—The works at Plymouth were established by Mr. William Cookworthy, who has been already mentioned in the notice of Kaolin (p. 141). Lord Camelford united with Cookworthy in obtaining a patent, and establishing the works. His Lordship in a letter to Mr. Polwhele says:—"The difficulties found in proportioning properly those materials, so as to give exactly the necessary degree of vitrification, and no more, and other niceties with regard to manipulation, discouraged us from proceeding with this concern, after we had procured a patent for the use of our materials, and expended on it between two and three thousand pounds. We then sold our interest to Mr. Champion of Bristol."—(*See Prideaux's Relics of Cookworthy.*) Plymouth porcelain is distinguished by its great hardness; it has become extremely valuable, and several excellent pieces, bearing the characteristic mark—the symbol for Jupiter—are preserved in this collection.

**BRISTOL PORCELAIN AND EARTHENWARE.** *Cases XXII., XXIII.*—It is known that Mr. Richard Champion commenced the manufacture of porcelain in 1768. Cookworthy and Champion appear to have been associated at one time in the manufacture, but in 1773 the patent right passed into Champion's sole name. He transferred the patent to a company of Staffordshire potters probably in 1781, and the Bristol manufacture was then abandoned. Fine examples of Bristol porcelain are eagerly sought by collectors; the small collection here exhibited shows the characteristic features of the ware, and the mark, a cross, which was usually employed. There is also a collection of specimens of old Bristol earthenware and delft on the lower shelves of these cases. For a full history of the works the

visitor should consult Mr. Hugh Owen's *Two Centuries of Ceramic Art in Bristol*.

**ROCKINGHAM PORCELAIN AND EARTHENWARE.** *Case XXIV.*—The beautiful porcelain here exhibited was manufactured at Swinton, near Rotherham, Yorkshire. It takes its name from the Marquis of Rockingham, upon whose estate the works were established in 1757. At that time, however, it was only a factory for making coarse earthenware, and the porcelain was not produced until 1820. The famous brown glazed pottery known as "Rockingham ware" was also made here. The works were abandoned in 1842.

**WORCESTER PORCELAIN.** *Cases XXV. to XXX.*—The Worcester works were established in 1751, through the exertions of Dr. Wall, a physician of that city. The early productions of Worcester were mostly imitations of China and Japan wares. It was, however, highly esteemed for its good qualities, and this was probably due to the employment of the Cornish Kaolin. In 1783 the Worcester porcelain works were purchased by Mr. Thomas Flight, from whom they afterwards passed to Messrs. Flight and Barr. The history of the works will be found in Mr. Binn's *Century of Potting in Worcester*.

The large collection of specimens in this series serves to show the principal characters of the ware at different periods. Attention may be called to the early examples richly ornamented with birds and insects painted in panels on deep blue scale-pattern ground, and to specimens of early transfer printing on white glazed porcelain. The King of Prussia mug, dated 1757, is one of the most interesting examples in the collection. The successive stages in the development of the manufacture, up to the present day, may be traced by studying the series here exhibited.

**SALOPIAN POTTERY AND PORCELAIN.** *Cases XXXI. XXXII.*—A small pottery was established at Brosely, in Shropshire, about the year 1751, and a superior kind of porcelain was afterwards manufactured under Mr. Thomas Turner, who came from the Worcester Works in 1772. The Coalport or Coalbrook Dale Works, still existing, were founded by Mr. John Rose, who originally settled at Jackfield, and then removed to Coalport, and ultimately purchased the Caughley Works. Examples of both the old and the modern products are exhibited.

A large series of specimens of Messrs. Maw's modern majolica ware, manufactured near Brosely, in Shropshire, is exhibited on the upper-shelves of wall-cases XXXIX. to XLIV.

**SWANSEA POTTERY AND PORCELAIN.** *Cases XXXIII., XXXIV.*—About the year 1753, a pottery was established at Swansea; in 1802, Mr. Lewis Weston Dillwyn purchased the works and introduced great improvements in the character of the ware and its decoration. It was not, however, until 1814, that the beautiful paste of the Swansea porcelain was produced. The Swansea porcelain is remarkable for the correctness of the natural history subjects with which they are embellished, Mr. Dillwyn having been much devoted to the study of this science. In 1817 the porcelain manufactory was abandoned, earthenware alone being produced until the works were finally abandoned in 1820.

**NANTGARW PORCELAIN.** *Case XXXIV.*—Several examples of the fine porcelain made at Nantgarw will be found in this case. The manufacture was commenced in 1813 by two famous workmen, *Billingsley and Walker*, and the works were purchased in 1820

by Mr. Rose, of Coalport, whither the plant and workmen were removed.

LOWESTOFT POTTERY AND PORCELAIN. *Case XXXIV.*—A small collection, illustrating these manufactures, is here exhibited. The production of porcelain was attempted at Lowestoft, in 1756, and successfully carried out the following year. The period of greatest prosperity was between 1770 and 1800; in 1802 the works were abandoned.

The series illustrating the history of the manufacture of British porcelain is here concluded, but it remains to notice several interesting collections of old English earthenware, which will be found in the lower parts of the wall-cases running along the western wall.

LEEDS WARE, &c. *Case XXXV. to XXXIX.*—It was in 1760 that pottery was first manufactured at Leeds. In 1786 it must have been in a flourishing condition, Mr. Green, the then proprietor, publishing a book of patterns, of which a copy is in the library of this Institution, with the title of "*Designs of sundry articles of Queen's or cream-coloured earthenware, manufactured by Hartley, Greens, and Co., at Leeds pottery. The same enamelled, printed, or ornamented with gold to any pattern; also with coats of arms, cyphers, landscapes, &c., Leeds, 1786.*" The potter's field is still known by that name in Leeds, and the bone-mill has only disappeared within a few years. The visitor will observe the fine cream tint of much of the Leeds ware, its brightness and elegance of form, and the delicacy of the perforated work which forms so marked a feature in its decoration. Associated with the Leeds ware are a few examples of the products of other Yorkshire potteries, such as the *Don, Castleford and Ferrybridge works*. There is also an extremely rare specimen of *Place's ware*, manufactured at an early date at the Manor House, York. We then pass to the samples of *Liverpool pottery*. According to Mr. Mayer, the first notice of Liverpool pottery occurs in the year 1674. During the last century several manufactories were in existence, the principal being those of Alderman Shaw, Messrs. Sadler and Green, Chaffers, and Pennington. Some large delft punchbowls of Liverpool ware are exhibited, and also some specimens from the *Herculaneum pottery*, on the opposite side of the Mersey, established in 1794 and abandoned in 1841.

In an adjacent case will be found examples of old *Newcastle, Nottingham, and Wrotham* ware; whilst the shelf above is devoted to the exhibition of modern ware, including the beautiful terra-cotta made at *Watcombe*, near Torquay, and the ornamental stone manufactured at *Lambeth* by Mr. Doulton, and decorated in an original style by Miss Barlow and other artists. The old productions of *Lambeth, Vauxhall, and Fulham* are to be found on some of the lower shelves of the cases against the western wall; and the bottom shelf of these cases supports a fine series of old *Delftware*, partly English and partly Dutch. Here will be found some curious examples of delft wine-pots, caudle-cups, pill-slabs, puzzle-jugs, punch-bowls, and dishes ornamented with rude figures of the kings and queens of England from Charles II. to Queen Anne. A few examples are exhibited of modern *Irish porcelain*, made at Belleek, in county Fermanagh, and notable for the beauty of its lustrous glaze and the elegance of form, copied from natural objects.

In the gallery a series of illustrations of ancient and modern specimens of *Foreign Pottery and Porcelain* is in course of arrangement.

Among the specimens will be found examples of ancient pottery from Mexico, Peru, New Granada, India, Barbary, Etruria, and

Rome: and of modern Mexican, Indian, Egyptian, Zulu, Italian, Portuguese, and Spanish pottery. Of Chinese porcelain some specimens will be found with the enamels, &c., in Case 53.

It has not been considered necessary to do more than introduce very brief descriptions of the objects in the Collection of Pottery and Porcelain, since the specimens are described in detail in the *Catalogue* specially devoted to this Department.

## GLASS.

*Cases 56, 57, 65, 68, 69.*

The manufacture of glass, from its intimate relation to certain branches of ceramic art, receives appropriate illustration in this section of the Museum.

Glass consists of a fused mixture of various acid silicates, usually transparent and insoluble, and always destitute of crystalline structure. In a free state silica or silicic acid is highly refractory, but when associated with certain metallic oxides, the resulting compounds are often eminently fusible. The degree of fusibility enjoyed by these artificial silicates is dependent partly on the nature of the base and partly on its proportion, those silicates which contain an excess of base being most fusible, and therefore most easily worked. In practice, however, glass always contains a large preponderance of silica, since it happens that the basic silicates, especially those of the alkalis, are frequently soluble, and hence to a great extent useless for those purposes to which glass is ordinarily applied. As an example of a soluble alkaline silicate, we may refer to the "water-glass" already mentioned at p. 45.

Excluding those oxides which are introduced simply as colouring or decolouring agents, the bases practically employed in glass-making are potash, soda, lime, and oxide of lead, but for these bases other oxides may be substituted, as in the zinc- and manganese-glasses exhibited in Case 56; whilst, on the other hand, the silica may be replaced by boracic acid, as in Faraday's "heavy glass," a silico-borate of lead, of which a specimen will be found in the same case.

*Devitrified Glass.* Case 56.—One of the most essential properties of glass is its amorphous or non-crystalline character. Its component silicates, as definite chemical compounds, possess a certain tendency to crystallize, but the rapid cooling of the fused mass effectually prevents crystallization. If, however, the glass be maintained long in a heated condition, its individual silicates have opportunity to crystallize, and the glass then, losing its vitreous characters, becomes *devitrified*. From their complex composition bottle and crown glass are most susceptible of suffering this molecular change, and several specimens of bottle "metal" are exhibited in which certain silicates, having separated, appear as crystalline products embedded in a vitreous matrix. Under other conditions the entire mass of glass may be devitrified, as in "*Réaumur's porcelain*," of which samples are exhibited. This peculiar substance is prepared by subjecting glass for a considerable time to a temperature somewhat below its melting point, the result being an opaque white fibrous product, exceedingly hard and tough, and capable both of withstanding sudden alternations of temperature and of resisting the action of chemical agents.

*FLINT GLASS.* Case 56.—This is composed of a mixture of silica, alkali, and oxide of lead. Specimens of the raw materials will be found in this case. Formerly the silica was introduced in the shape of calcined flints, whence the name "flint" glass, but at the present

day sand alone is employed. The chief localities in England for glass-making sand are Alum Bay, Lynn, Aylesbury, Wareham, Reigate, and the New Forest; but it is not always of sufficient purity for flint-glass manufacture. Large quantities are also derived from Fontainebleau, in France, and from America, Australia, and New Zealand. The sand is prepared for use by simple washing and calcining, or if necessary by treatment with hydrochloric acid. The alkali in flint glass is usually employed in the form of pearlash, an impure carbonate of potash, the acid being expelled during fusion. The high lustre, great density, and easy fusibility of flint glass are due to the presence of oxide of lead, which is largely introduced into its composition, chiefly as red lead.

To remove the colour imparted to the glass by impurities in the raw materials, especially iron and carbon, certain oxidizing agents are always mixed with the raw materials. Of these oxygen-yielding substances, the most common are nitre or saltpetre, arsenious acid or white arsenic, and pyrolusite or peroxide of manganese (p. 84).

The following recipe for the composition of fine flint glass was given by the late Mr. Apsley Pellatt:—

Carbonate of potash	-	-	1 cwt.
Red lead or litharge	-	-	2 cwt.
Sand washed and burnt	-	-	3 cwt.
Saltpetre	-	-	14 lbs. to 28 lbs.
Oxide of manganese	-	-	4 oz. to 12 oz.

The ingredients reduced to powder, and mixed with a due proportion of "cullet," or broken waste glass, are fused together in fire-clay melting pots, covered with a hood or dome, to prevent the flames from affecting the "batch," or mixture. One of these crucibles is placed in the western gallery, and the mode of arranging the pots is shown in the model of a flint-glass furnace which is placed in this case. These pots are filled but once a week in a flint-glass house, usually on Friday or Saturday morning. The various charges are melted down and fresh matter supplied, until in about 12 or 15 hours the pot is full of melted metal. Air bubbles and striæ then abound, and they are not expelled until 30 or 40 hours have elapsed; during that period the glass becomes homogeneous. Saturday and Sunday are the days when the furnace requires the greatest heat, so that the working may be commenced on Monday morning. When the melting and refining are completed, the temperature is lowered until the metal becomes sufficiently viscid and plastic to admit of free working.

The details of manipulation are illustrated by a series exhibiting the successive stages in the manufacture of a wine-glass; and several of the simple tools of the glass-worker are exhibited, viz., the *pucellas*, the *spring tool*, and the *wood tool*. The mode of blowing glass in metallic moulds is also illustrated.

The finished article passes from the hands of the glass-blower at a high temperature, and is immediately transferred to the "leair," or annealing oven, to prevent the excessive brittleness resulting from sudden cooling. It has been already stated that the particles of melted glass possess a certain tendency to crystallize, but that this tendency is resisted by the rapidity of cooling. The conditions, therefore, being unfavourable for crystallization, the particles are forced to assume a constrained position, which is necessarily greatest at the surface, where the cooling has been most rapid; and hence the superficial layers are in a state of tension in relation to those beneath, the slightest force being sufficient to disturb the unstable equilibrium and produce disruption. The curious "Bologna

*phials*" placed in this case are samples of unannealed glass, and the well-known "*Rupert's drops*" are similar examples. The object, therefore, of annealing is to cool the glass with sufficient slowness to prevent the inconvenient brittleness of unannealed glass, but at the same time to avoid such tardy cooling as would induce devitrification.

The final operations of grinding, polishing, and engraving are illustrated by specimens; and a collection of modern objects in flint glass will be found in Case 69, described at p. 161.

Among other specimens in the case before us attention may be directed to an example of *cameo incrustation* of much interest. The figure, usually made of porcelain clay and sand which has been previously fused with carbonate of potash, is formed in a plaster of Paris mould, and slightly baked. It is then heated to redness, and being placed within a cylindrical flint-glass pocket, the open end is heated and welded together by pressure, so that the figure is in the middle of a hollow hot mass of glass. The whole is re-warmed and the workman exhausts the air by his mouth from within, by means of the tube to which it is attached, and thus by atmospheric pressure the whole becomes a homogeneous body.

An *incrusted inscription* is another example of a similar character: the letters are drawn upon a piece of glass with a vitrified black paint, and burnt in; the inscribed glass is introduced at nearly a red heat into a glass pocket, and treated as already described. Bricks of glass containing inscriptions are now inserted in the foundation stones of buildings, to tell the tale of the founders, and of the state of this manufacture, ages after the bodies of those who fabricated either are resolved again into their primary elements.

**BOTTLE GLASS.** *Case 56.*—The various stages in the process of forming a wine bottle are here shown. The raw materials employed in the manufacture of common bottle-metal are of the coarsest description, consisting usually of rough sand, soapers' waste (the alkali employed), gas limes, common clay, and rock salt; but the composition is by no means uniform in different works.

**PLATE GLASS.** *Case 56.*—All the cases in the building may be regarded as examples of plate glass; and the glass in the roof shows the character of the roughened plate. Some examples in these cases furnish instances of peculiarities.

The composition of plate glass varies considerably; sand, salts of soda, or of potash, lime, and "cullet" or broken glass in different proportions are introduced. Peroxide of manganese, arsenic, and saltpetre are employed as decolorizing agents; and often oxide of lead, to impart a brilliancy to the glass. The manganese and the other substances are used to secure the oxidation of the iron, or carbon, which may exist even in the purest materials. An excess of manganese produces a violet colour; and even when at first there is no appearance of colour in the glass, it will upon exposure to sunshine be gradually developed. Instances of this pink or violet tint are exhibited in the cases before us, and the same thing is strikingly shown by much of the plate glass in the roof of the building.

Plate glass is cast upon flat metallic tables, or casting plates, which are warmed previously to the flowing of the glass from the *cuvette* or crucible to prevent its cooling too rapidly; when properly spread, which occupies but a short time, five minutes only being required, it is passed into the annealing oven, where the plate remains from 8 to 14 days.

The annealing process being completed, the plate is subjected to the operation of polishing, which is effected by means of *colcothar* (*oxide of iron or crocus*), rubbed over the plates with a heavy muller or weighted board.

The various stages in grinding and polishing the plate are illustrated by a series of specimens.

**CROWN AND SHEET GLASS.** *Western Gallery.*—In the gallery above the pottery on the western side will be found a series showing every stage of the process of manufacturing sheet and crown glass, with examples of the tools employed.

*Crown glass* is composed of a mixture of sand, soda-ash, and lime, which, after partial fusion in a "fritting oven," is mixed with a proper proportion of cullet, or broken refuse glass, and the whole melted in a glass pot. When thoroughly fused the workman gathers upon the end of a long iron blowpipe a sufficient quantity of the melted glass; and having flattened the mass by rolling upon a "marver," or iron table, blows a pear-shaped flask, which is enlarged by repeated reheating and subsequent blowing. When sufficiently enlarged, the glass globe is transferred to the "pontil" or punt, and the blowpipe having been removed, the "flasher" rapidly rotates the heated globe, which, expanding by the centrifugal force developed by rotation, is finally converted into a flat circular disc; and this, after removal from the punt, is conveyed to the annealing oven: the point at which the punt adhered, being thicker than the surrounding portion, forms the mark called the "bull's eye."

The manufacture of *sheet or spread window glass* differs somewhat from that of crown glass. Instead of being blown into the shape of a globular flask, the ball of melted glass is extended into a conical form by a swinging motion, and then elongated into a cylinder, which is cut open by means of a drop of cold water falling along a line which has been previously heated by the application of a red hot iron; the cylinder is then flattened upon what is called the spreading plate, or the flatting stone, and the sheet of glass so formed subsequently annealed.

*Miscellanea.*—*Case 56* includes, in addition to the objects already described, a series of modern *Venetian enamel cakes* (p. 164), and a collection of *glass beads* used in the African and Indian trades. The art of making glass beads was first discovered at Murano, where the trade is still great; it is stated that they make 200 different shades of colour. Here also will be found pieces of *enamelled glass*, formerly manufactured at Bristol; and some examples of painted and etched glass, &c. *Etching on glass* is commonly effected by covering the glass with a coating of wax, and then with a needle removing it along the lines to be etched. The drawing being formed, the glass is exposed to the action of hydro-fluoric acid, liberated from fluor-spar by the action of sulphuric acid and heat.

The remaining objects in this case are for the most part sufficiently explained by the accompanying labels.

In the Historical Series the following will be found to be of especial interest. The importance of a collection of ancient glass, accompanied by analyses thereof, in connexion with modern illustrations of the use of sands and alkalis, must be evident to every one.

**ANCIENT GLASS.** *Case 57.*—The tradition of the discovery of glass by the accidental fusion of sand on the bank of the river Belus can scarcely be received; evidence appears to throw the discovery very

much further back in time. It is clear that in the age of Moses and Job the art of making glass was known, and it is evident, from the examples preserved in the Egyptian tombs, that the people of those days were familiar with the processes of pressing and moulding glass (*see examples*). Babylonia, Assyria, and Chaldea have each afforded specimens, which prove not merely that the fusion of silica with an alkali could be effected—this was shown by the enamelled bricks—but that this fused mass could be variously coloured and worked into articles of ornament. The researches of Layard, Rawlinson, and Loftus have brought us the beads and other ornaments worn by the ladies of the days of Assyrian splendour, found in the great room of the palace of Nimroud; while amidst the relics of brick-built Babylon similar illustrations of the fictile art have been found (*see examples*).

The specimens of *Greek glass* of the same general character have considerable interest, as showing the progress of this manufacture; and we must associate in our consideration those illustrations of glass which are regarded as *Roman*, having been found at Nîmes, and Trèves, and in London, associated with other relics, marking the spots which Rome included within the bounds of her empire.

It will be observed that these glasses are variously coloured, that some show the process of moulding, others are blown, and some have been cast or else flattened. The Pompeian and Roman architects are known to have used glass in their mosaic decorations; and glass is said to have been employed for admitting light to the houses in Pompeii. Some of these examples of glass have been analysed in the laboratories of the establishment: the following are the results:—

	Silica.	Alumina.	Protoxide of Iron.	Protoxide of Manganese.	Lime.	Magnesia.	Soda.
Vase glass - - -	70.58	1.80	0.53	0.48	8.00	trace	18.86
Flatted glass - - -	71.95	trace	3.45	0.57	7.33	0.60	15.30
Lachrymatory - - -	71.45	2.15	1.02	0.17	8.14	trace	16.62

The cinerary urns of green glass will be inspected with much interest; of these Mr. Apsley Pellatt writes, "The round vases are of elegant forms, with covers and two double handles, the formation of which must convince any one capable of appreciating the difficulties which even the modern glass maker would have to surmount in executing similar handles, that the ancients were well acquainted with the art of making round glass vessels." One of the bottles found at Nîmes has been formed by being blown in a mould. The *lachrymatories* have been so called from the romantic notion that those bottles were filled with the tears of the mourners for the dead, as they have been usually found in tombs; the received opinion among the antiquaries of the present day is, that they contained the unguents and aromatics which it was usual to deposit with the dead.

The *Roman glass beads*, from the number of them which have been discovered in various parts, must have been much in use. It is curious and interesting to find rock crystal and agate beads associated with glass; thus indicating the value which must have been

set upon the white transparent glass of those days. In this case will be found some examples of Druidic beads. These beads were called *Glain Neidyr*, from *glain* pure and holy, and *neidyr* a snake. It is curious to find these beads in the ancient British tombs, in the graves of our Roman conquerors, in the tumuli of the Anglo-Saxons, and at the present day in the Ashantee district of Africa; while a bead in all respects similar is made in Venice.

Another set of beads found in Britain are shown; these consist of glass and rock-crystal, and were found with iron weapons in a stone-sided grave within a tumulus, near the Tynwald Hill, Isle of Man.

**VENETIAN GLASS.** *Case 65.*—Venice for a long period during the middle ages was celebrated throughout Europe for its glass. Familiar with the manufacture from an early date, the Venetians, on the capture of Constantinople in 1204, profited by their intercourse with the East, and glass factories soon became so numerous at Venice, that towards the latter part of the thirteenth century they were removed to the adjacent island of Murano. During the fourteenth century the art was principally directed to the production of beads and other trifles, but a fresh impulse was given to the manufacture on the fall of the Eastern empire; and during the fifteenth and sixteenth centuries Venice produced those peculiar examples of glasswork, which, from their ingenuity of design and delicacy of execution, acquired a wide reputation, and for a long time, defying imitation, enabled Venice to maintain a monopoly of the manufacture. The case before us contains a fine collection of these skilful productions, of which the principal varieties may be briefly described.

*Vetro di trina* is fine lacework, with intersecting lines of white enamel or transparent glass, forming a series of diamond-shaped sections, the centre of each having an air bubble of uniform size; this glass was executed almost with the precision of engine lathe turning. The large cup and cover is a fine example of this variety, and there are some other smaller specimens. *Case 56* contains some specimens made in imitation of the old *vetro di trina*.

*Frosted Glass.*—The art of making this glass appears to have been lost until it was revived in the Falcon Glass Works about 1850. Mr. Apsley Pellatt thus describes his process: "It has irregularly veined marble-like projecting dislocations with intervening fissures. Suddenly plunging hot glass into cold water produces crystalline convex fractures, with a polished exterior like Derbyshire spar, but the concave intervening fissures are caused, first by chilling and then reheating at the furnace, and simultaneously expanding the reheated ball of glass by blowing, thus separating the crystals from each other, and leaving open fissures between, which is done preparatory to forming vases or ornaments. Although frosted glass appears covered with fractures, it is perfectly sonorous." The ancient frosted glass is represented in *Case 65*; the modern in *Case 56*.

*Filigree Glass.*—Filigree canes of plain, coloured, or opaque white are arranged in a mould, a solid ball of flint glass is then heated so that the canes of glass adhere to it; these are marvered or rubbed into an uniform mass; it is then covered with a gathering of white glass, and is formed into any shape.

*Case 66.*—The series of ancient Venetian glass is continued on the lower shelf of this case, and several varieties are here represented which were not exhibited in the preceding cases. These include examples of the Venetian ball, Schmeltz glass, &c.

"*The Venetian Ball* is a collection of waste pieces of filigree glass conglomerated together without regular design; this is packed into a pocket of transparent glass, which is adhesively collapsed upon the interior mass by sucking up, and thus producing outward pressure of the atmosphere."—(Pellatt.) An interesting ball is in the collection, in which a dark purple glass, covered with air bubbles, is enclosed in a transparent glass of another character.

"*Millefiore* is more regular in design than the ball, but of the same character. It was formed by placing lozenges of glass, cut from the ends of coloured filigree canes, ranging them in regular or irregular devices, and encasing them in transparent glass."—(Pellatt.)

*Schmeltz Glass*, the character of which may be seen in the specimens at the southern end of the case, was formed by welding together variously-tinted glasses until the colours become irregularly blended and the mass assumed somewhat the appearance of a variegated marble.

The *Venetian Plate* and another specimen of opaque glass appear to resemble in many respects Réaumur's porcelain (p. 155).

OLD GERMAN GLASS, &c. *Case 66.* This case contains several interesting examples of early German glass. The tall cylindrical beakers, ornamented with escutcheons and other designs in opaque enamel colours, were peculiar to Germany during the sixteenth and seventeenth centuries; and two of the specimens before us bear the date 1655. A smaller drinking glass, with a delicately executed painting in brown camaïeu, furnishes an example of the style of monochrome decoration practised by the Germans in the seventeenth century.

Some specimens of old Dutch and French glass are also placed in this case. On the upper shelf is a goblet of engraved glass, formerly used by Charles II. Through Sir Robert Gayer, one of his courtiers, it came into the possession of the Hodgson family. As showing the make and the engraving of glass in the seventeenth century this specimen is interesting.

MODERN ORNAMENTAL GLASS. *Cases 68, 69.*—Before passing to the strictly modern examples of glass-making, attention may be called to a few specimens of *old Bristol glass* arranged on the upper shelf in *Case 68*. Much of the modern glass was obtained from the great Exhibition of 1851, and is noteworthy for its beauty of colour and elegance of decoration.

*Yellow Glass.*—The fine yellow on the specimens in these cases are produced by *silver*; the yellow of the ordinary glass for ornamental windows may be produced by charcoal, iron, or antimony.

*Canary Yellow*, or Uranium yellow, is the result of the combination of the oxide of uranium with the flint glass. This glass has some peculiar optical properties. If we look *through* any thickness of a coloured mass it is purely yellow, but if we look *at* any surface of it upon which the light falls it appears green. This phenomenon is possessed by uranium glass, in common with a solution of sulphate of quinine, an infusion of horse-chestnut bark, and some varieties of fluor-spar. The investigation of this peculiar dichroism was first entered on by Sir John Herschel, who observed that the effect was confined to the first surface of the body, and hence he spoke of it as *epipolism*; but the thorough examination of the subject was reserved for Professor Stokes, who shows that the rays thus rendered visible to us do not belong to the ordinary prismatic spectrum, having a

much higher degree of refrangibility than any of the Newtonian rays. To distinguish those rays Professor Stokes proposed, as they are very beautifully shown by fluor-spar, to give them the name of *fluorescent rays*.

*Ruby and Red Glass.*—The finest reds on the vases, &c., are produced by the *purple of Cassius*, which may be regarded as a stannate of tin with a stannate of oxide of gold; or by a solution of gold in *aqua regia* (*nitro-hydrochloric acid*).

The Bohemian ruby is thus prepared:—a preparation called *schmelze* is made; it is composed of silica 500, minium 800, nitre 100, calcined potash 100. The gold solution contains 155 grains of gold in a quart of *aqua regia*, which is then mixed with five times its bulk of water;  $\frac{1}{80}$  of this gold solution is mixed intimately with 512 parts of *schmelze*, 48 of borax, 3 of oxide of tin, and 3 of oxide of antimony, all in a state of fine powder. The whole is then heated for 12 or 14 hours in an open crucible placed in a glass furnace, and then suffered to cool in an annealing oven.

The ordinary red glass is produced by *copper*. The sub-oxide of copper possesses a colouring power of remarkable intensity, the smallest quantity reddening glass so deeply as to render it almost opaque—hence glass is usually only coated or *flushed* with the red glass produced by the sub-oxide of copper. Glass containing sub-oxide of copper does not exhibit its colour on leaving the crucible; it is, in the first instance, nearly colourless, with a slight tinge of green, but it becomes deep red when, after having cooled, it is heated a second time at a lower temperature. H. Rose supposed this curious phenomenon to be due to the formation of an acid or neutral silicate at a high temperature, and that the subsequent softening at a low temperature causes the decomposition of this compound, and a separation of some sub-oxide of copper which colours the glass.

Many examples of *flashing*, or spreading one colour upon another over white glass, are in the case. By cutting down through those layers to different depths, a very ornamental appearance can be produced. (*See also Case 56*, where the process of cutting is illustrated).

Some common red glass is produced by iron.

*Amethystine Glass* is produced by the peroxide of manganese.

*Green Glass* is obtained by the protoxide of iron, but a finer colour by the oxide of copper. Glass, coloured green by oxide of copper, has a remarkable power in stopping back the solar heat-rays. Melloni found that an apple-green copper glass, made in Italy, prevented the permeation of at least 80 per cent. of the heat-rays. The author of this Guide discovered that the smallest quantity of the oxide of copper, in glass free from manganese, possessed the property of stopping all the *parathermic* rays: these are rays of low refrangibility, found below the red rays of the Newtonian spectrum. To these heat-rays the scorching of plants is especially due.

Glass prepared by Messrs. Chance, Brothers, upon this principle has been employed in glazing the great palm-house in the Royal Botanical Gardens at Kew with the most satisfactory result. It has been observed that greenhouses glazed with the old green crown-glass are more favourable to vegetation than such as are glazed with the more agreeable white sheet-glass.

*Blue Glass.*—Oxide of cobalt is used for producing the fine blues which we see in flint glass. One thousandth part of cobalt will give a very deep blue to glass, and one twenty thousandth will impart a very perceptible tint. The preparation of *smalts* or *saïfre* has been described. (*See p. 114*).

*Threaded Glass.*—This is prepared in the manner noticed under Venetian glass (p. 160).

*Millefiore.*—Examples of these modern imitations of, and improvements on, the old Venetian are shown; and a specimen exhibiting the manner in which the sections of canes are disposed previously to their being enclosed in a mass of transparent glass, accompanies the specimens.

It will be evident, that having once enclosed these coloured canes in a mass of glass, it can be readily formed into tazze or vases, as shown in the finished examples in *Case 68*.

*Engraved Glass.*—Some very fine specimens are shown, especially in *Case 69*. The ordinary tools used in engraving glass are discs of copper, some as large as a halfpenny, and others mere copper pencils which are moved by a lathe; these tools are smeared with oil and emery. The hard grains of the polishing material penetrate the mass of the soft metal during the process, and form a species of file, which in revolving cuts into the softer glass.

*Aventurine Glass.* *Case 68*. See also Venetian examples and No. 596 in Horse-shoe *Case*.—This is an ordinary glass, which owes its colour to the sub-oxide of copper; and the brilliant laminæ are probably metallic particles, produced by the addition of some powerful reducing agent to the melted copper glass.

**ARTIFICIAL GEMS.** *Case 69.*—*Strass*, so called after its inventor, is a glass possessing in the highest degree purity and transparency, combined with the greatest possible lustre. It is a mixture of quartz, boracic acid, purified caustic potash, and a large proportion of oxide of lead, introduced in some specimens of strass as red lead, and in others as white lead. With perfectly pure and colourless strass, the colouring agent is combined—the following being a few examples:—

*Topaz*, antimony and gold; *Ruby*, purple of Cassius; *Emerald*, oxide of copper or chromium; *Sapphire*, oxide of cobalt; *Amethyst*, cobalt and gold; *Beryl*, antimony and oxide of cobalt; *Garnet*, gold, antimony, and manganese; *Opal*, bone ashes, oxide of uranium, and forge scales, or, in some cases, oxide of nickel.—(*Knapp*.)

**ARTIFICIAL PEARLS.** *Case 69.*—At an early period the practice of making hollow glass beads, and filling them with a pearly varnish, was adopted. Beads were thus made by some artists at Murano, but the government of Venice considered the invention too fraudulent, and prohibited its practice.

A French bead maker, Jaquin, revived and improved the art. He observed that the small fish called in France *ablette*—the bleak, *Cyprinus alburnus*—filled water in which they were washed with fine silver-coloured particles. The water on standing deposited a sediment which had the lustre of the most beautiful pearls; this led him to attempt the manufacture of pearls from it. He scraped off the scales of the fish, and called the pearly powder which was diffused through the water, *essence d'orient*, or essence of pearl. He first covered beads made of gypsum with this; but as the ladies who wore them found the pearly powder left the beads, and adhered to the skin, the use of those ornaments fell off. The beads were then made of glass—a glass easily melted and made a little bluish, being drawn into tubes, which were called *girasols* (the word signifying opal). From these tubes hollow globules were blown, and they were then covered on the inside with a solution of isinglass and the pearl essence, which was blown in warm and spread over the internal surface by rapid motion. When dry, the globules were filled with wax, bored through with a needle, and strung on threads. These

beads are still made of all shapes and sizes, and many of the most perfect imitations are sold at good prices. The bleak is a fish of about four inches long, caught only in fresh water ; to obtain a pound of scales, 4,000 fish are necessary, and those do not produce four ounces of pearl essence, to preserve which sal ammoniac in solution is used. The optical effect is produced in the same manner as in the real pearl, the grooves of the pearl being represented by the inequalities of the laminae formed by those particles removed from the scales of the fish.

#### ENAMELS.

##### *Table-cases 60 and 61. Model of Tomb No. 59.*

Enamelling, or the process of covering metals or stones with a vitreous substance, or of running enamels into portions which have been previously removed by a graver, is of high antiquity. There was but a step from the enamelled bricks of Babylon to the enamelled bronzes of the Romans, or the shrine enamels of the Byzantine empire.

A series of historical specimens illustrating this art will be found in Table-case 61. Commencing with some Roman enamels found near Eden in Cumberland, we have next a Byzantine enamel on gold of the 11th century, being a portion of the "gold altar" front obtained from Constantinople by the Doge Pietro Orseola. This is followed by a reliquary of the 13th century, enamelled in the style called *champ levé*. These shrines or reliquaries were in common use, and were usually decorated with some legend of the saint to whom they were dedicated. In the *champ-levé* process those parts of the design intended to appear in enamel are hollowed out in the metal ground, leaving the outline in slender elevated partitions, or bands of metal: the intaglio portions are then filled in with the coloured vitreous substance introduced in the state of powder and afterwards fused ; the surface of the whole being finally smoothed by grinding and polishing.

In the 14th century we have a priket candlestick from Dijon in *champ-levé* enamel, and a monstrance ornamented in a different style of enamelling, the design being here chased upon a silver plate, and the surface then covered with brilliant transparent enamels, through which the design appears. The 15th century is represented by an enamelled processional crucifix from Italy, and from this we pass to the much admired *Limoges enamels* of the 16th century. These are painted enamels of considerable merit, usually executed *en grisaille* on a dark ground, and relieved by the introduction of flesh tints and touches of gold: the works of the later artists are however frequently coloured, as seen in the polychrome enamels of the 17th century here exhibited. From the painting of enamel pictures, the art was extended to the decoration of metallic vases and other ornamental objects, of which the enamelled tazza in this case is an example. Among the Limoges enamels will be found works by Limousin, Raymond, Nouaillier, Laudin, and the master I. M. From the coloured enamels of Limoges we advance to what may be termed the enamel painting of modern times.

*Enamel painting*—properly, painting on enamel—is fully illustrated in Case 60. The white cake enamel used as the painting ground, and the beads and pipe employed as a flux, are all manufactured in Venice. These appear to consist of about ten parts of lead and three parts of tin, converted into oxide by heat and exposure. To the mixed oxides are added ten parts of quartz and two

parts of common salt, and the whole fused together. The enamel being reduced to powder, is spread over a plate of copper or gold and exposed to a strong heat; the enamelled plate is then coated with flux, and again fired and ground down, as shown in the specimens. This is the surface upon which the enameller has to work. He takes metallic oxides, these he mixes with the flux and paints his picture. An enamel painting has to pass many times through the fire, consequently great care is required in this part of the work.

No fault can be corrected, the fire fixes the colours as applied, and whether good or bad they are unchangeable. The various colours employed are shown.

Mr. Hone was probably the first who ventured to paint large enamels; a small work by this artist, of the date 1749, is in this case. Mr. H. Bone, R.A., by whom there are several beautiful works, exceeded all before him in the size of enamel paintings, his Bacchus and Ariadne, the original of which is in the National Gallery, measuring 18 inches by 16½. The portrait of Sir Henry De la Beche was painted on enamel from the life by Mr. H. P. Bone, and presented by him to the Museum: this, from the difficulties of the art, is not often attempted. There are other examples by the same artist.

The modern French Limoges enamels, and another, together with the portrait of the celebrated Saussure, by Constantin, painted in 1845, will show the state of this art on the Continent.

*Model of the Tomb of William de Vallence (No. 59).*—William de Vallence, senior Earl of Pembroke, half brother to Henry III., died in 1304, and was buried in Westminster Abbey. His tomb was decorated in the costly style of the period. Not only were the portions of the original enamelled, which are copied in the model, but that part also which is here represented in wood appears to have been covered over with brass plates richly enamelled. This is intended as an illustration of the history of the applications of enamel to the decoration of tombs. The figure is of brass, cast by Mr. Beattie, and gilt by the electrotype process; the enamelling by Robert Ainger, and the base of Caen stone by H. C. Smith, constructed under the superintendence of the late Albert Way, Esq., F.S.A.

*Chinese Enamels, Glass, &c.*—In Case 53, on the eastern side, will be found some specimens illustrating the art of enamelling amongst the Chinese. From a very early period this nation has been in the possession of the art of enamelling metals, and of painting on enamelled surfaces. The large plaque and the bowl are examples of ancient *cloisonné* enamelling, differing from the *champ-levé* process already described, inasmuch as the outline is here formed, not of the plate itself, but of separate narrow bands of metal bent into the required shape, and attached to the ground. These incrustated enamels are accompanied by several examples of superficial enamelling; and with these are associated various specimens of Chinese pottery and glass in course of arrangement.

#### MOSAICS. *Table-case 54.*

Portrait of the Emperor of Russia, &c., on gallery stairs, eastern side. Head of Christ, &c., on western side.

In noticing the tessellated pavement in the lower hall, the pavements of Woodchester and of Cirencester have already been named. In this case are examples of ancient Roman tessellated pavements.

which show the manner in which they were constructed, and the kind of design which is usually found. Many of those Roman pavements are not only interesting as relics of this great people, but they are beautiful works of art, and they must have been the result of immense labour and great skill. A portion of a mosaic pavement found at Halicarnassus is mounted on the W. staircase,

The art of manufacturing glass mosaics was practised in old Rome, and the modern city is still the seat of this manufacture. The manufacture has, however, as might be expected, varied somewhat in character. As at present practised, thin rods of easily fusible glass of every variety of colour are prepared for the purpose. From masses of coloured glass are formed, first, slabs, and then the little rods exhibited; the artist softens these in the flame of his lamp, draws out the rod into a thick thread, and breaks off a piece of the thickness of the intended picture. The design of the picture is copied from a cartoon, and the pieces are placed in proper order on a sheet of copper, covered with a cement which serves for fixing the picture; when the whole slab is covered, the surface, which is uneven and unsightly from the unequal lengths of the rods, is ground and polished. After the removal of the polishing powder the interstices between the rods are filled with wax, which corresponds in colour with the different parts of the picture. Some large examples of modern mosaic work are near the glass on the east side. The largest known mosaic picture is taken from the Lord's Supper of Leonardo da Vinci, which is 12 feet high, and twice as long; it is said to have occupied eight or ten artists daily during eight years. The Byzantine mosaics differ from the others only in the artistic character of the productions. A larger example of this work is the Head of Christ, on the western staircase: whilst on the opposite side are two modern mosaics, of large size, one the portrait of the late Emperor of Russia, executed in 1828, and presented to the Museum by the Cavaliere Barbieri.

The *opus incertum* (Terrazo or Pavimento Veneziani) is in common use in the north of Italy for floors, the colours being given to the lime by ochres. The *lime ash* floor of England is another variety of the same composition.

The pieces from the walls of Pompeii show the kind of *stucco* used, and the general character of the paintings in the houses of that city. It will be seen that these are not in fresco, but ordinary paintings on the cement employed.

## THE MODEL ROOMS.

In the very limited number of pages which can be appropriated to a notice of the objects in this section of the Museum, it is impossible to introduce anything beyond the most brief descriptions: this, however, is the less to be regretted, since a special catalogue of this department has been prepared by Mr. Bauerman, to whose descriptions the visitor seeking further information is in all cases referred.

The Model Rooms are situated at the northern or Piccadilly end of the building, and comprise an eastern and a western room on the principal floor, marked respectively A and B; with a small supplementary apartment, C, approached from the lower gallery. As these rooms are not provided with gas, they are necessarily closed at dusk.

On the right-hand side of the entrance to the eastern room (A) is a model illustrating the plan adopted to *condense lead fumes at the Wanlock Head Works*, in Clydesdale (p. 65). *Flat and round chains* for mining purposes are fixed on each side of the doorway, and in front of these are three models of different forms of the *man engine*,—a German invention for facilitating the descent and ascent of miners. It was originally introduced in the Hartz in 1833; the large model on the right hand represents one erected at Fowey Consols in Cornwall in 1851. It will be seen that in some of the forms the engine has but one rod and therefore one series of platforms, whilst others are furnished with a double rod. Immediately on entering the room will be found, on the left-hand wall, a *sectional model of the workings of Dolcoath Mine*, near Camborne (M. 4)—one of the oldest, if not the very oldest, of the existing mines in Cornwall. The red wood in the model represents *granite*, and the white the *killas* or Cornish clay slate; the lode being shown by the black layer which extends over both these rocks. It should be understood that the spectator is to suppose the granite and slate are entirely removed from the side of the lode nearest to him, and that he looks upon a vertical section of the lode, and the workings by which the metalliferous portions have been removed. The description of this model in the earlier editions of the Guide has been transferred to the Catalogue of Models. A case of *safety fuses and cartridges* is placed above the model of Dolcoath. The table at this end of the room is occupied by models of various forms of *whims*, or machines for raising minerals in mine-shafts.

A large and very perfect working model of *Taylor's engine* (H. 5) at the United Mines, in Gwennap, occupies a prominent position in the centre of the room. The celebrated Cornish pumping engine, of which this is a model, performed the high duty of lifting one hundred and ten millions of pounds one foot high by the consumption of a single bushel of coal (94 lbs.) in the fireplace of the boilers.

On the table on the right-hand side of the entrance will be found a model of a *Welsh blast furnace and blowing machine* (N. 24). The air from the cylinder of the blast engine before entering the furnace flows through the regulator—represented by the large copper sphere—and, when the hot blast is employed, likewise passes through a system of heated cast-iron pipes, the arrangement of which is also shown in the model. The remainder of the table-space is occupied by a model of a *double-cylinder blast-engine*, used at the Royal Saxon Smelting Works, on the Mulde. Passing over the models of pumping engines on this side of the room, we reach the large model of a *water pressure engine at the Alport mines, Derbyshire* (H. 4). This model, when viewed from below, shows the shaft in which the pumps are placed by which the water is drawn from the mine. Above is the tube for the column of water, by the pressure of which the machine is moved. At the Alport mines and *adit level* or *sough* is driven to the mines from the banks of the river Derwent, a distance of three miles, so as to drain the mines to the depth of about 22 fathoms; and the water from the workings below this level is raised by three large hydraulic engines, of which the most successful was the one here represented, constructed at the Butterley Works from the designs of Mr. Darlington.

Opposite to this model is a small *stone breaker* made on Blake's principle by Messrs. Marsden of Leeds. Machines of this kind are now largely used for crushing ore as well as for breaking stone for road metal. A stand of *wire ropes* is fixed above the fireplace, in front of which stands a *Cornish crushing machine* used in the dressing of copper ore. At this end of the room will be found several illus-

trations of *boring machinery*, the surface arrangements being represented by model C. 21, while the tools actually employed are mounted near the spiral staircase. On the left-hand side of the fireplace stands a large model (C. 22) of two forms of boring apparatus with free-falling cutters adapted for deep borings. Close to this is a model of a *water wheel* which represents one of a pair employed at the Devon Great Consolidated Mines. These mines consist of Huel Maria, Huel Fanny, Huel Anna Maria, Huel Josiah, and Huel Emma. They are situated on one of the banks of the river Tamar, near Tavistock, among most beautifully-wooded hills. The wheels are worked by a stream of water taken from the river at a higher level. One set of wheels is employed in draining the mine, and another for sending water over the hill to supply the dressing floor of the mine.

Next to the model of the Devon Consols wheel is a model of a similar vertical *water wheel* used for pumping at Wheal Friendship, near Tavistock. On the metal table opposite, in the centre of the room, stands a model of the *turbine or horizontal water wheel* (H. 3) on Fourneyron's principle.

Along the northern wall is a series of cases containing *tools employed in various mining districts*; and by examining these the miner of any one country or district at once becomes acquainted with the description of tools employed in another. Near the entrance to Room B. is a case devoted to tools employed by the colliers in the North of England. Close to this stands a case of tools used by the metal miners of Cornwall, and including also some specimens showing the structure of different forms of *safety-fuse*. Here also will be found some samples of *electric fuses*, and on the lower shelves a few *ancient mining tools*. The next case is appropriated to Saxon tools, and the succeeding case to the tools used in the lead mines of Derbyshire and Flintshire. These are followed by a case of Mexican tools, and these in turn by examples of tools employed in the collieries of South Wales. Then follows a case containing mining tools used in Flintshire, and also a set of Russian tools. Finally, there is a case devoted to the tools used at Schemnitz, in Hungary, where the mines yield ores of gold, silver, lead and copper.

Leaving the eastern model room, the visitor enters the second apartment (B.), which is devoted chiefly to illustrations of colliery workings. On the left side of the entrance, however, there is a model of *Jordan's pumps with rods of wire rope*. Immediately facing the entrance we find a model (A. 16) representing the *physical features of a coal district*, showing the outcrop of the beds of coal, and how they are affected by faults or troubles. On the right side of the visitor on entrance is a model (G. 3) illustrating different methods of *working and ventilating coal mines*, which are sufficiently explained by the accompanying descriptive label. Next to this stands a *model of the Forest of Dean* (A. 14) by Mr. Thomas Sopwith. It represents a tract of country comprising the principal coal-field of the Dean Forest, the superficial area being 24 square miles. The *outcrops or bassetting* of the principal beds of coal are shown on the surface, and vertical sections of the strata are painted on the sides of the model. In order to show similar vertical sections in the interior of the Forest, the model is made in compartments, placed on a sliding table, so as to be easily separated.\*

\* It is important, to avoid injury, that the models should not be touched, except by persons acquainted with them. For any special purposes, permission to examine this and other models minutely may be obtained, but the public are especially requested not to attempt to open the models.

A model (F. 15) in the centre of the room represents a *colliery pit frame* by Mr. W. H. Jordan. The drawing ropes, proceeding from the drum in the engine house, pass over the guide rollers at the top of the shear frame, and are attached to the cages, or covered platforms, running on guide rods, and provided with safety catches. Behind the pit frame stands a *model of Ebbw Vale and Sirhowy Iron Works in the county of Monmouth* (A. 13). This model is by Mr. Sopwith; it comprises nearly four square miles of ground. The upper surface being taken off, the *black-pins mine*, a vein of ironstone, with the workings in it, appear. Below this the *three-quarter coal*, *modelling coal*, and *red vein mine* are exhibited by removing successive trays which represent the intervening strata.

In front of the fireplace is one of *Ridley & Co.'s coal cutting machines*, worked by compressed air. This machine, which has been introduced into several collieries, is intended to supersede manual labour in undercutting or "holing" in coal. By the side of this is an example of *Messrs. Jones and Bidder's apparatus for superseding gunpowder* in collieries. A hole is first bored in the face of the coal by means of the spiral drill, and a steel cylinder in two parts is then introduced into the hole; steel wedges are afterwards inserted between the parts of the wedge and forced in by hydraulic power; they thus exert pressure in all directions, and the coal is consequently broken mechanically as it would be if gunpowder had been employed, whilst the danger of firing a shot in the explosive atmosphere of a mine is completely avoided.

Over the fireplace is a large screen bearing a number of *ancient processional tools* from Saxony. It is interesting to note how the several parts of a timberman's axe have become conventionalized and rendered useless in these ornamental tools. On the right side of the fireplace are two *natural sections*, one of the coal seams near Barnsley, the other of ironstone deposits in North Lincolnshire.

At the end of the room are two large *models of Shipley Colliery, in Derbyshire* (G. 1 and 2), presented by Messrs. Woodhouse and Jeffcock. From these accurate models an excellent idea may be obtained, not only of the most approved surface arrangements of a large colliery, but also of the underground workings. G. 1 shows the method of working the coal and the course of the ventilating currents, whilst G. 2 exhibits the winding machinery at the surface, with its steam engine, &c. Near G. 1, and occupying the greater part of one side of the room, is a large model (F. 52) of a *self-acting inclined plane* at the Upleatham iron mines, in the Cleveland district of Yorkshire. The ironstone, which is obtained from the marlstone or middle lias, is brought from the mine in small waggons and emptied at the tipping cages into larger waggons. The train of loaded trucks is lowered down the inclined plane by the drum, whilst a train of empty waggons is being drawn up. At the back of this model, against the adjacent wall, is a natural section of the *coal measures at the Rosebridge pits near Wigan*. The Rosebridge colliery has reached a depth of 815 yards, and is notable as being the deepest in this country. By the side of this section is a fine *specimen of the Better-bed coal* of Bradford in Yorkshire. The specimen exhibits a section of the entire thickness of the bed, and shows the character of the adjacent strata. The "better-bed" coal is interesting for exhibiting under the microscope vast numbers of the spores of coal-measure plants. Under the model G. 3 is a *sample of the Brora coal* worked to a limited extent in the Oolitic rocks of Sutherland, whilst a *sample of Indian coal* from the Runigunge coal-field stands

under an adjacent case. On the wall beneath the windows of this room is a series of glass-cases containing a collection of *cages and safety skiffs*, among which will be found illustrations of several recent inventions. In most of these contrivances it is arranged that upon the breaking or cutting of the rope the cage or bucket shall be gradually or suddenly brought to rest by being wedged against the guides in which it travels.

Returning to the eastern model room, and ascending the spiral staircase at the S.E. corner, the visitor reaches the eastern end of the gallery leading to the third model room, C. On the north side of this apartment is a large German model (M. 6) illustrating the various *mining and dressing operations as conducted in the Saxon lead mines* at the close of the last century; and in the centre of the room stands a model representing the *surface workings of a small Cornish tin-mine* (M. 3). Here will also be found a number of models illustrating various modes of supporting the ground in mining excavations by *timbering and masonry*, and of protecting wet colliery shafts by *cast-iron tubing*. In front of the fireplace is a small *hand crusher*, employed in some of the Derbyshire lead mines; and on the shelves in the south-east corner of the room is a series of *geological models* by Mr. Sopwith, whose descriptions of them have been transferred to the Catalogue of Models.

Passing from this apartment to the gallery of the model rooms, we find at the head of the staircase a model of a *crane used for shipping large blocks of sandstone* at the Redhall quarry, near Edinburgh (F. 53). On the adjacent table stands a model of a *lead chamber for condensation of sulphuric acid vapour*, produced by the oxidation of sulphurous acid (N. 35); and the *reverberatory furnace* at the side (N. 36) is designed for the production of sulphate of soda by the action of sulphuric acid on common salt, the sulphate being afterwards converted into soda-ash. The next model (N. 34) represents *Mr. Young's apparatus for the manufacture of stannate of soda*, a salt prepared by the reaction of tin-stone and caustic soda; and this is followed by a model (N. 15) illustrating *Pattinson's process for desilverizing lead*, which has been described at p. 116. The remainder of the table-space in this gallery is occupied by models representing several forms of *blast furnace*, some of which are provided with arrangements for utilizing the waste gases from the top of the furnace.

The four wall-cases in this gallery are appropriated to *models of metallurgical furnaces*, distributed as follows:—in Case 1 are several Saxon furnaces for lead smelting, with a Belgian zinc, and a Cornish tin-furnace; Case 2 contains the apparatus employed in the Saxon processes for silver extraction; the next, Case 3, is devoted to iron furnaces, including a model of Whitwell's hot-blast fire-brick stove; and the last, Case 4, contains models of North of England lead-hearth, with a model illustrating Siemen's process of making steel, and one of Siemen's regenerative gas furnaces, &c. In the regenerative furnace the heat is obtained from combustible gases (carbonic oxide and hydrogen), which are produced in the "generator," and are heated prior to combustion by passing through a mass of brick-work which has been heated by the products of previous combustion.

At the western end of this gallery is a glass case filled with a large series of *crystallographic models* in wood and glass; while larger models adapted for the lecture table will be found on the upper shelves of the wall-cases in the large room on the ground floor.

Occupying the table-space in the western gallery are illustrations of several *plans for ventilating mines*, together with models of *buddles, jiggling frames*, and other *dressing machinery*.

Commencing at the entrance to this gallery, the first Wall-case No. 5, presents a large display of *mining lamps*, among which the *safety or Davy lamp* for coal mines merits especial notice.

It will be seen that this is a lamp surrounded by wire gauze. The principles of its construction, arrived at by Sir Humphry Davy, by a very beautiful series of inductive researches into the character of flame, are the following:—Gas, in a state of combustion, will not pass through fine apertures. Hold a piece of wire gauze above a gas flame; it will be found that the flame will not permeate the gauze, although all the gaseous products of combustion pass it with great facility. The light carburetted hydrogen gas, formed by changes taking place in the bed of coal, forms, when mixed with air, an explosive mixture, which is far too frequently of the most destructive nature. This gas passes freely through the wire gauze into the flame, and it is ignited *within the lamp*; but as the flame cannot pass out, no explosion takes place on the outside of the wire. When the carburetted hydrogen gas becomes in excess, the light of the lamp is extinguished. The miners complain of the deficiency of light from the original Davy, and hence various improvements have been introduced, of which several are here exhibited. Among the most recent may be mentioned Crag and Bidder's magnetic lamp, which when locked cannot be opened except by placing the lamp on a powerful magnet, when the iron bolt is withdrawn by attraction.

Among the objects in the next case are several forms of *pyrometer*, or instruments for measuring higher temperatures than those capable of being recorded by ordinary thermometers. The most noteworthy of these is the ingenious electrical pyrometer devised by Mr. Siemens.

Passing over the *windlasses* and *ventilating machines* in this case, we find the next section appropriated to *Gay Lussac's apparatus for assaying silver by the wet way*, that is, by precipitating the silver as chloride by the action of a solution of common salt, a method first adopted at the French mint. The remaining wall-cases in this gallery—the arrangement of which is not yet completed—contain models of *dressing machinery*, described in detail in the special Catalogue of Models.

## THE LOWER GALLERY.

### THE PALÆONTOLOGICAL COLLECTION.

The two galleries, with the exception of the recesses in the upper gallery, are devoted to the illustration of the Fossil Geology of the British Isles. In this Guide it will not be necessary to do more than indicate the general order of arrangement, and to point to the larger groups; referring for further information to the *Catalogue of the Collection of Fossils*, which, in addition to a complete inventory of specimens, contains a valuable sketch, by Professor Huxley, of the general principles of natural history and their application to the elucidation of Fossils or Palæontology.

*Palæontology* is the science of ancient life, the name being derived from *παλαιός*, *palaíos*, ancient; *ὄντα*, *onta*, beings; and *λόγος*, *logos*, a

discourse or doctrine. The palæontologist, therefore, seeks to learn the order in which the forms of life have been developed, and he endeavours to make safe deductions from the discoveries of the geologist, by which he may advance scientific truth, and thus necessarily increase its powers of practical application.

The divisions which have been adopted for the purposes of grouping together rocks with especial reference to their organic remains are as follow:—

Primary	{	Lower Palæozoic	{	Laurentian.
			{	Cambrian.
Secondary	{	Upper Palæozoic	{	Lower Silurian.
			{	Upper Silurian.
	{		{	Devonian.—Old Red Sandstone.
			{	Lower Carboniferous.
			{	Upper Carboniferous.
			{	Permian.
Tertiary	{	Lower Mesozoic*	{	Triassic.—New Red Sandstone.
			{	Lower Oolite.
	{	Upper Mesozoic	{	Middle ditto.
			{	Upper ditto.
			{	Lower Cretaceous.
			{	Upper Cretaceous.
Post-tertiary.	{	Eocene†	{	Lower Eocene.
			{	Middle ditto.
	{	Meiocene.‡	{	Upper ditto.
			{	
	{	Pleiocene.§	{	Older Pleiocene.
			{	Newer ditto.

This table commences with the oldest known sedimentary rocks (the Laurentian), and, neglecting minor subdivisions, proceeds thence in a regularly ascending scale. In arranging the fossils a similar plan has been adopted. The fossils are exhibited partly in the Flat-cases and partly in the Wall-cases, whilst a large number of specimens are placed in the drawers beneath the Flat-cases. In the following description the Flat-cases are distinguished by numbers in thin type (1), and the Wall-cases by thick type (1). In examining the Wall-cases it should be noticed that the numbering, unlike that of the minerals and rock-specimens, proceeds from the *lower* part of the cases, the bottom shelf being al ways regarded as the first.

#### PALEOZOIC FOSSILS.

In the *first of the Flat-cases* on the left-hand or western side of the gallery (1), and in the lower part of Wall-cases, sections 12 and 13, will be found the earliest indications of fossil remains which have yet been discovered in the lowest of the *Palæozoic rocks*, or those in which the indications of the most *ancient life* appear,—with the exception only of the *Eozoön*, detected in the *Laurentian* rocks of Canada, Bohemia, Bavaria, and elsewhere (p. 72). There are in the Cambrian rocks near Dublin two species of branched or plant-like organisms, probably Zoophytes, called *Oldhamia*. In rocks of

\* The middle forms of life, μέσος, middle, ζωή, life.

† The dawn of recent life, ἡώς, the dawn, καινός, recent.

‡ The less recent life, μείων, less, καινός, recent.

§ The more recent life, πλείων, more, καινός, recent.

the same age in Shropshire, known as the Longmynd beds, there are traces of worm-like animals (*annelids*), and a solitary trilobite, or what appears to be such; whilst many other trilobites have been found in the Harlech grits of St. David's. Fossils become much more numerous and varied when we ascend to that zone which has been termed by Mr. Hicks the Menevian beds, and which was formerly classed with the Lingula Flags. These Lingula beds derive their name from a small shell called the *Lingula*, while the Menevian beds borrow their designation from "Menevia," the classical name of St. David's. Among the Menevian fossils may be specially mentioned the large trilobite known as *Paradoxides*. The trilobites were crustaceans, or creatures remotely allied to the crabs and lobsters, but different from any crustaceans at present living. Many of the species were capable of rolling themselves up into a ball, like the common wood-louse, and many examples of these rolled-up trilobites will be found in the collection. The Lingula flags are followed by the Tremadoc beds, so named from the locality in North Wales where they are characteristically developed; and these in turn are succeeded by the Llandeilo flags, which take their name from a locality in Carmarthenshire. The fossils of the Lingula, Tremadoc, and Llandeilo beds are arranged in Flat-cases 1 to 3, and in Wall-cases, sections 12 to 13. In the wall-cases will be found numerous examples of the curiously serrated creatures called *Graptolites* by Linnaeus,—γράφω, *grapho*, I write, and λίθος, *lithos*, a stone,—from the resemblance of their remains in the stone to writing or sculpture. These graptolites are extremely characteristic of the Lower Palæozoic strata, and are abundant in the Llandeilo and other Lower Silurian rocks. Flat-cases 4 to 11, and Wall-cases, sections 14 to 16, are devoted to fossils from the Caradoc or Bala beds. The former name is taken from Caer Caradoc, in Shropshire, where shelly sandstones of this age occur; whilst the latter name is borrowed from Bala, in Merionethshire, where a fossiliferous limestone is found of approximately the same age as the Salopian sandstones. The Bala limestone has yielded a fine suite of fossils, including numerous trilobites, star-fishes, and mollusca. Among the mollusca, or "shell-fish," the most notable forms are those known to naturalists as *Brachiopods*, the characteristics of which have been already pointed out (p. 31).

Above these Bala beds occur the rocks which are named after the town of Llandovery in South Wales, and which are divisible into a lower and an upper group. The Lower Llandovery fossils will be found in Flat-cases 12 and 13, and the Upper Llandovery in Nos. 13 to 15; whilst both upper and lower are distributed through Wall-cases, sections 17 to 19. The classification of these beds is a matter of some difficulty; the Lower Llandovery, however, are placed by the Survey in the Lower Silurian series, while the Upper Llandovery beds form the base of the Upper Silurian group. Succeeding the Upper Llandovery rocks we have the Woolhope beds, whose fossils are exhibited in Flat-cases 15 and 16; then the Wenlock shales, represented by fossils in Cases 16 to 18; and above these, the Wenlock limestone which has yielded the fine series of fossils in Cases 19 to 22. The Woolhope and Wenlock specimens are continued in the Wall-cases, sections 17 to 24. By far the greater number of the fossils in this series have been obtained from the Wenlock limestone, which forms a conspicuous ridge in Shropshire, and is often known as the Dudley limestone. The trilobites are extremely abundant in this formation, one of the most common (*Calymene Blumenbachii*) being known to collectors as the "Dudley locust." Attention may be specially

drawn to the remarkably fine example of the trilobite called *Homalotus delphinoccephalus*. Nor should the remarkable examples of crinoids, or stone lilies, escape attention (p. 30); whilst the corals are represented by a large number of species such as the well-known "chain coral" (*Halysites catenularius*). Continuing the examination of the Flat-cases the visitor finds in Nos. 23 and 24 the fossils of the Lower Ludlow, and in 26 to 28 those of the Upper Ludlow rocks; the intermediate Case, No. 25, being occupied by the fossils of the Aymestry limestone, among which the characteristic *Pentamerus Knightii* is especially conspicuous. The Ludlow series is continued in Wall-cases, sections 25 to 27, whilst the succeeding sections 28 and 29 are devoted to large specimens of Upper Silurian Crustacea (animals with a crust-like covering, such as we see in crabs and lobsters), among which may be remarked especially the remains of the great *Pterygotus*, a crustacean six or seven feet long. In the next section, 30, will be found remains of some of the oldest fishes known,—*Pteraspis*, *Onchus*, &c.,—from the "Ludlow bone bed," which occurs just beneath the Downton sandstone; and from the beds, formerly called tilestones, and considered to be the base of the Old Red Sandstone, but now classed with the Uppermost Ludlow rock, and as beds of passage to the Devonian rocks. It should be remarked, however, that the remains of fish have been found in the Lower Ludlow rocks, and that these are at the present time the oldest known examples of *Vertebrata*, or animals possessing a backbone of jointed segments, such as is possessed by all fishes, reptiles, birds, and mammals.

The class of fishes which thus makes its first appearance, so far as we know, in the Upper Silurian rocks, becomes well represented in the overlying Old Red Sandstone or Devonian rocks. The Devonian fish will be found in Wall-cases, sections 30 and 39 to 41; the latter containing some fine examples of *Coccosteus*, *Pterichthys*, and the other Old Red Fish of Scotland; whilst the Devonian shells, corals, and other invertebrate fossils are displayed partly in Wall-cases, sections 31 and 32, and partly in Flat-cases Nos. 29 to 35. Some of these fossils are of interest from the support which they lend to Professor Ramsay's view that the Old Red Sandstone was for the most part deposited in great fresh-water lakes.

Above the Devonian or Old Red rocks come the beds forming the Carboniferous series. Flat-cases Nos. 36 and 37 contain fossils from the Lower Carboniferous beds; 38 to 47 contain a selection of the fine organic remains yielded by the Carboniferous or Mountain limestone (p. 30); 47 is devoted to fossils from the Millstone grit; and 48 and 49 to animal remains from the coal measures. Turning to the Wall-cases, the Carboniferous series is continued in sections 33 to 35, where the beautiful corals of the Carboniferous limestone form a characteristic feature; in sections 36 to 38, where the fine examples of Cephalopoda attract attention; in 42 to 45, which contain remains of Carboniferous fish; and in 46 and 47 which are devoted to the fish and Labyrinthodonts of the coal measures. These Labyrinthodonts—so called from the curious structure of their teeth as displayed in microscopic sections—were air-breathing creatures belonging to the class Amphibia, which contains the frogs, toads, and newts, and which may be separated from the Reptiles by having their respiration effected in early life by means of gills. Some idea of the prolific flora of the coal-measure period may be gained by studying the plant-remains in sections 48 to 54. These remains teach us that a great variety of plants, of decidedly terrestrial habit, flourished through that long period of time to which the formation

of most of our numerous coal beds must be referred. *Cryptogamous* or flowerless plants, in their general character like ferns, mosses, club-mosses, and horse-tails; and *coniferae*, an order of plants which, like the fir and pine, bear cones in which the seeds are contained, furnished the chief elements in the flora of the carboniferous rocks. From such vegetable productions as these, growing in great luxuriance under the influence of an elevated temperature, and decaying with much rapidity in an atmosphere charged with moisture, our coal beds appear to have been formed (*see Catalogue of Rock Specimens*, 3rd ed., p. 66).

The coal-measures are succeeded by the Permian rocks, forming the uppermost of the Palaeozoic series. The mollusca from this formation are grouped together in Flat-cases 50 and 51; and the fish remains in Wall-case, section 46.

Before closing the notice of the Lower Gallery it should be mentioned that the Table-case in front of Wall-cases, sections 45 to 47, is devoted to specimens illustrating the structure of a reptile called *Stagonolepis Robertsoni* from the Triassic sandstone of Lossiemouth in Elginshire (*see* Professor Huxley's paper in Quarterly Journal of the Geological Society, vol. xxxi. p. 423). The neighbouring Table-case in front of sections 50 to 52 contains examples of Ichthyosaurian fossils from the secondary rocks. The Table-cases on the opposite or western side are appropriated to fossils of much more recent age, which will be duly noticed at p. 178.

At the head of the staircase, on the western side, will be found the remains of *Ichthyosaurus*, including a fine specimen from the lower lias of Street; and on the stairs of the eastern side, a remarkably perfect *Plesiosaurus*, from the same locality, with a miscellaneous collection of the remains of reptiles from the secondary rocks. The ichthyosaurus was a gigantic reptile of aquatic habit, furnished with a long tail, and with paddles resembling those of the whale; it was a creature of great size, some specimens attaining to upwards of 24 feet in length. The plesiosaurus was another extinct aquatic reptile of large size, and furnished with paddles resembling those of the ichthyosaurus, from which it differed however in general form, its most distinctive characters being found in its comparatively small head and extremely long neck. Restorations of these extinct saurians may be seen in the grounds of the Crystal Palace at Sydenham.

## UPPER GALLERY.

*Commencing at the left hand or eastern corner.*

### SECONDARY AND TERTIARY FOSSILS.

Passing over the few plants and other organic remains found in the Trias or New Red Sandstone of this country (*see* Wall-case, sections 8 and 9, bottom shelf), we find in the first Flat-case (No. 1) fossils from certain rocks lying between the trias and the lias, and known as the Penarth or Rhætic beds. The earliest known reptiles, *Stagonolepis* and *Telerpeton*, occur in what is generally regarded as New Red Sandstone, and are represented in Wall-case, section 26, which contains also other reptilia from the secondary rocks.

Occurring in extraordinary abundance, and in an excellent state of preservation, the fossils of the Liassic and Oolitic formations re-

cessarily demand a somewhat large amount of space. The group of liassic rocks, forming the lowest member, is represented in Flat-cases 1 to 6, and in Wall-cases, sections 8 to 13. *Ammonites*—so called from the resemblance of this shell to the curved horn on the head of Jupiter Ammon—thronged the waters at this time, and gigantic cuttle-fish have left their internal “bones,” known as *Belemnites*, *Βελεμνιτις*, *belemnites*, a dart,) to tell of their abundance. In Wall-case, section 17, are some fine specimens of the *crinoidal* animals of the lias; and a collection of lias fish from Lyme Regis is arranged with the Oolitic vertebrata in sections 22-24.

The subdivisions of the *Lower Oolites*, embracing the Inferior Oolite, Fuller's Earth, Stonesfield slate, Great Oolite, Bradford clay, Forest Marble, and Cornbrash, are represented by an extensive series of fossils, displayed in Flat-cases 7 to 21, and Wall-cases, sections 11 to 16. No. 18 is devoted to certain plant remains from the lower Oolites, consisting chiefly of arborescent ferns, and of plants allied to the existing *Cycas* and *Zamia*.

The strata known as Kellaway's rock, Oxford clay, Calcareous Grit, and Coral Rag, form together the group of *Middle Oolites*, the characteristic fossils of which will be found in Flat-cases 22-26, and Wall-cases, sections 14 to 21. The organic remains from the Kimeridge clay—the lowest of the *Upper Oolitic* series—are placed in Flat-cases 27 and 28; those from the overlying Portland beds in 29 and 30; and the fresh-water shells from the Purbeck rocks in 31 and 32. Turning to the Wall-cases, we find in sections 22-25 specimens of Liassic and Oolitic fish; in 26, some interesting reptilian remains from the Oolites; and in 27 a collection of fossil insects, &c. from the Purbeck group.

The lower division of the Cretaceous system embraces the Wealden beds and the Neocomian or Lower Greensand; the fossils from the former—for the most part fresh-water shells—are in Flat-case 33; while Cases 34 to 40 contain Neocomian fossils. The *Gault*, a band of clay separating the Lower from the Upper Greensand, is represented in Cases 41 to 43, and in this series the beautiful fossils from the Folkestone Gault are especially conspicuous. The Blackdown beds of Devonshire have yielded the fine fossils in Nos. 44 and 45, whilst the Upper Greensand has contributed the large series exhibited in Nos. 46 to 49; the Coprolite deposits worked around Cambridge having furnished many of the latter fossils. The Chloritic Marl is represented in No. 50, the Lower Chalk in 51, and the Upper Chalk in 52 and 53. Turning to the Wall-cases, we find in sections 28 to 30 a collection of sponges, crustaceans, cephalopods, &c., from the Neocomian beds and the Gault; in sections 31 to 33 the Neocomian and Gault fossils are continued on the lower shelves, whilst the bulk of the case is devoted to specimens from the Upper Greensand of Cambridge and Wiltshire, from the Blackdown beds, from the Chloritic Marl, and from the Red Chalk: the last is a deposit which occurs locally at the base of the White Chalk, and is exposed at Hunstanton on the coast of Norfolk, and at Speeton Bay in Yorkshire. Then in sections 34 to 37 the series from the Upper Greensand is concluded, and the fossils of the Chalk form the bulk of the collection. The Cretaceous Vertebrata, mostly fish, are exhibited in sections 38 and 39, but for want of sufficient space here, part of the collection is placed in the drawers of the Table-cases in the *Lower Gallery*.

Having now reached the close of the secondary epoch, we advance to the tertiary division, including the Eocene, Miocene, and *Pliocene* groups.

Commencing with Flat-case No. 54 we find a selection of fossils from the Thanet sands, which overlie the chalk; then in 55 we have fossils from the Woolwich and Reading beds, or the "Plastic clay" of the older geologists; and from the London clay—the thick deposit of stiff clay on which the metropolis is seated. In No. 56 the London-clay series is continued, and in Cases 56 to 59 the Bracklesham beds are represented by a series of beautiful marine shells. Cases 59 to 61 contain a set of equally fine fossils from the Barton series; and the remaining cases are devoted to the other Upper Eocene fossils, including the Headon series in Cases 61 and 62; the Osborne and St. Helen's beds in 62; and the Bembridge and Hempstead series in 63. In connexion with this Eocene collection it should be mentioned that the gastropods will be found in the drawers beneath the Flat-cases.

Eocene fossils of a different character, including plants, echinoderms, cephalopods, and vertebrata, are exposed in the adjacent Wall-cases. In section 47 we find fossils from the Thanet beds, the Woolwich and Reading series, and the London clay. Section 48 contains fossils of the Lower Bagshot, Bracklesham, Barton, Headon, Bembridge and Hempstead beds. Section 49 is devoted to Eocene fish, whilst 50 contains reptiles, with a few remains of birds; and 51, the Eocene mammalia.

The Miocene plants, chiefly from the lignite-beds of Bovey Tracey, in Devonshire, are grouped together in Wall-case, section 52. The fossils of the Pleiocene deposits, known as the Craggs of Suffolk and Norfolk, are exhibited in sections 53 to 56; whilst the remaining cases are devoted to a collection of post-pleiocene fossils.

The Craggs are generally divided into the white or Coralline Crag, the Red Crag, and the Norwich or Mammaliferous Crag. Each of these sections is well represented, many of the finest fossils having been obtained from the workings for the so-called coprolites, extensively carried on in the Red Crag.

To continue our survey of the palæontological collection, it is necessary to return to the Lower Gallery, where 11 sections of the Wall-cases, and two Table-cases on the west-side are devoted to Pleiocene and Post-pleiocene fossils, mostly vertebrata. In Wall-case, sections 1 and 2, we find a collection of vertebrate remains of Pleiocene age from the Craggs of East Anglia. Prominent among these are the large ear-bones of extinct whales, and the teeth of *Mastodon*, a creature related to the elephants, but having teeth furnished on the grinding surfaces with ripple-like projections. The succeeding sections of the Wall-cases 3 to 11 are devoted to the remains of Post-pleiocene mammalia. Here will be found some fine specimens from the brick-earth of Ilford and Crayford, including numerous examples of extinct species, such as the teeth of the woolly-haired rhinoceros (*Rhinoceros tichorhinus*), of the mammoth (*Elephas primigenius*), and of other species of elephant no longer living. The last section of this series of cases, No. 11, contains some interesting specimens of mammalian remains from Kent's cave near Torquay, in Devonshire, and from the Wookey Hole hyena-den in Somersetshire. In these caves we find many of the extinct Post-pleiocene mammalia, such as those here represented, associated with the earliest known remains of our own species. These ancient relics of man occur in the shape of rudely-worked unpolished flint implements, such as have already been described at p. 61. Before leaving this collection, attention should be directed to the fine skull of the musk ox, or rather sheep, (*Oribos moschatus*), which was found by Professor Boyd Dawkins in the brick-earth of Crayford in Essex, and now stands in section 7. The musk sheep is at present a native of Arctic America, but in common

with other northern mammalia must have inhabited this country during part of the Pleistocene period.

Our survey of this department would be incomplete without reference to the two adjacent Table-cases, which contain a remarkably fine collection of fossils from the Forest bed of Cromer on the coast of Norfolk. For more than 40 miles along this coast the remains of a buried Forest are to be found; and associated with the stumps of trees are numerous antlers of deer, teeth of the elephant and rhinoceros, and other relics of the terrestrial fauna of the period. The present collection, which was got together and presented by the Rev. S. W. King, contains some fine specimens of *Cervus Sedgwickii*, *Trogonotherium Cuvierii*, *Rhinoceros etruscus*, *Elephas meridionalis*, and other mammals, some of which are still living, whilst others are extinct.

Such is a rapid outline-sketch of this valuable collection of fossil remains, the study of which will be greatly facilitated by observing on the Geological Maps and Sections the order which the respective formations observe to each other. Especially in the *Memoirs of the Geological Survey and Museum of Practical Geology* will information be found on these and other important allied subjects.

#### GEOLOGICAL ROCK SPECIMENS.

The PETROLOGICAL COLLECTION, or COLLECTION of GEOLOGICAL ROCK SPECIMENS will be found in the recesses of the second gallery. A catalogue of these is published under the direction of Professor A. C. Ramsay, but although three editions have been issued they are at present exhausted. It is only necessary, in this place, to give a general notice of the principal groups.

The series of IGNEOUS ROCKS are arranged chiefly on the western side, commencing at the south-west corner with Wall-case No. 1, in which will be found some interesting examples of lavas and other volcanic products, from the promontory of Aden, at the mouth of the Red Sea, and from Kilauea and Hawaii, in the Sandwich Islands. These are followed by a series of diorites, trachytes, and other igneous rocks from certain mining districts in Hungary, Croatia, and Transylvania. In this case are also grouped a few specimens from the Eifel, St. Vincent, and Teneriffe.

Wall-case 2 contains a tolerably extensive set of igneous rocks from Ascension Island, and the Galapagos Archipelago, presented by Mr. Darwin.

New Zealand also furnishes some interesting volcanic products, which are here exhibited.

The following case, No. 3, is occupied by a collection of specimens from the extinct volcanoes of the Rhine, and from the Island of Maderia. On the upper shelves of Cases 2 and 3 are some very characteristic models of limestone, gneiss, and other rocks, together with a model of the island of Bourbon.

Before passing to the next compartment it is desirable to notice the objects in the recesses on this side of the gallery. In the first recess, opposite Case 2, is an instructive model of *Arthur's Seat, Edinburgh*, showing the geological structure of that volcanic hill; and in the next recess, opposite No. 4, is a Table-case (A), containing a model of Vesuvius, and an extensive series of Vesuvian rocks and minerals. With these are associated some specimens from Hecla, and some samples of melted Rowley Rag (p. 47). In the same case will be found an instructive model of Graham's Island, an island

which was thrown up in the Mediterranean, near Sicily, in the summer of 1831, and, after continuing some time in a state of violent eruption, gradually diminished in size, and finally disappeared about three months after its first appearance.

In the Table-case B, occupying the next recess, is a geological model of Etna, together with a valuable collection of volcanic products from Etna, and from the extinct volcanoes of the Papal States.

Leaving the series of modern volcanic products, we turn to those rocks in which the igneous origin is less obvious, although still indubitable; such, for example, as the basalts. These are represented in the remaining Wall-cases in the recesses on this side of the gallery; and with these truly igneous products are associated certain rocks of questionable origin, such as granite, serpentine, &c. As most of these have been already described in connexion with the objects in the hall, it will be necessary merely to give the references where such notices may be found. The series commences in Wall-case No. 4 with a collection of the different varieties of *granite* (p. 24), from which we pass through the group of *syenites* to the *greenstones* (p. 27), with which are exhibited samples of the *ash*, and other mechanical accompaniments of the trappean rocks.

The upper and lower shelves of Case 5 are appropriated to examples of the columnar *basalt* and associated rocks in the neighbourhood of the Giant's Causeway (p. 47); and in the same case are grouped some fine specimens of Cornish *serpentine* (p. 29). The remainder of this case, and the whole of the following one, contain specimens forming part of the collection of British stratified rocks, to be presently noticed.

Table-case C, at the head of the staircase on this side, is devoted to *specimens illustrative of Glacial phenomena*.

The common form of a glacier is that of a river of ice, filling a valley, and pouring down its mass into other valleys yet lower. It is not a frozen ocean, but a frozen torrent. The Glacier moves on like a river, with a steady flow, although no eye sees its motion; but from day to day, and from year to year, the secret silent cause produces a certain slow effect. The movement of such a mass of ice as that which constitutes a glacier must be exhibited in enormous manifestations of force. Hence, we find the glaciers of the Alps grinding the rocks, on either side of the gorges through which they glide, with irresistible power. The specimens exhibited show the wearing and grinding force of the modern glaciers; and the discovery of similar scratches on the rocks of Snowdon and other places proves the presence, at one time, of glaciers in the mountain valleys of this country. See Professor Ramsay's Remarks on Glaciers, in the *Catalogue of Rock Specimens*, and in *The Old Glaciers of North Wales*.

Crossing to the opposite or eastern gallery, we commence notice of the collection of BRITISH SEDIMENTARY ROCKS. These are arranged stratigraphically, in ascending order (see Table of Strata, p. 172), commencing in Wall-case 40, with the lowest of the Palæozoic series, or oldest stratified rocks, represented by a small group of specimens from the *Laurentian* gneiss of the north-west of Scotland, and the adjacent islands. These are succeeded by the *Cambrian* grits, slate, &c., with their associated igneous rocks, chiefly from North Wales, the Longmynd, and Charnwood Forest. Above the Cambrian comes the *Silurian system*, the lower division of which comprises the *Lingula* and *Llandeilo flags*, the *Caradoc* or *Bala beds* and the *Lower Llandovery* rocks. Neglecting minor

subdivisions, the Upper Silurian series consists of the *Upper Llandovery* rocks and the *Wenlock* and *Ludlow* groups, including many beds of highly fossiliferous limestone. The Silurian rocks, which are chiefly from Wales, where they are very largely developed, are distributed through Cases 41, 42, and 43.

Between the Silurian and Carboniferous systems occur the slaty rocks of Cornwall and Devon, forming the *Devonian* group, and the strata long known as *Old Red Sandstone*, largely developed on the borders of Wales and in various parts of Scotland. The *Carboniferous system*, to which we now pass, is divided, in this country, into the *Carboniferous limestone*, *millstone grit*, and *coal measures*. The Carboniferous or Mountain limestone is especially prominent in the north of England, where it forms the Pennine chain (p. 30); in Derbyshire it is associated with the "toadstone" (p. 30), of which several examples are here shown. The millstone grit has been noticed at p. 36. The "coal measures" is a collective term applied to the alternations of shale, sandstone, fireclay, coal, and ironstone, which occur associated in most of our coal fields. In Cases 43 and 44 will be found representatives of the coal measures of South Wales, Dean Forest, Coalbrook Dale, Flintshire, South Staffordshire, Warwickshire, Lancashire, Derbyshire, Yorkshire, and Northumberland.

The *Permian* rocks, overlying the coal measures, and forming the uppermost member of the Palæozoic series, are represented by the conglomerates, dolomites, (p. 39,) &c. in Case 44.

Before concluding the examination of the Palæozoic rocks, attention should be given to the Table-cases in the recesses on this side of the gallery. These cases, marked respectively D, E, F, are appropriated to a collection of *Scotch rocks from the Old Red Sandstone and Carboniferous systems*, including a large series of the associated igneous rocks.

Turning to Case 45 we find the lower rocks of the secondary or Mesozoic epoch, commencing with the *New Red Sandstone* or *Trias*. Above the Trias are the fossiliferous rocks known variously as the Penarth, Rhætic, and Westbury beds. These deposits form a transition to the overlying *Lias* (p. 37), a group of clays, argillaceous limestones, and marls, regarded usually as the base of the Oolitic system, and divided into an upper and a lower group, separated by the marlstone. The limestone of the *Oolites* have been noticed at p. 37; and the numerous subdivisions of the system at p. 176; each of these finds its representatives in Case 46.

The remainder of the collection of British stratified rocks will be found on the opposite side of the gallery in Cases 5 and 6, to which we now re-cross. The Oolitic series is continued in Case 5 (north side); the fresh-water deposits known as the *Purbeck* beds being there represented. Then follows the *Lower Cretaceous* group, comprising the *Wealden* beds and the overlying *Lower Greensand*, or *Neocomian*.

The *Gault*, *Upper Greensand*, and *Chalk*, forming together the *Upper Cretaceous* series, receive illustration in the following Case, No. 6; where also will be found the Tertiary or Cainozoic rocks. These are divided into the *Eocene*, *Miocene*, and *Pliocene* groups (p. 172) of which the lowest, or Eocene, occupies two depressed areas in the chalk, known as the London and Hampshire basins, the latter extending to the Isle of Wight. These are followed by the *Miocene beds*, which are but feebly represented in Britain, occurring only at Bovey Tracey, and in the Isle of Mull, while the *Pliocene rocks* are represented by the *Craigs* of our eastern counties.

In this case are also grouped together specimens from the drift-gravels, boulder-clay, &c.; and, finally, in Case 6, we have a collection of specimens from raised beaches, caves, and other recent formations.

In front of the entrance to the Mining Record Office stands a model, by Professor A. Geikie, F.R.S., illustrating the geological structure of the *Isle of Eigg*, in the Hebrides.

Before leaving this part of the gallery, it should be mentioned that at the time this Edition of the Guide is being revised, (Autumn of 1876,) alterations are contemplated, by which the collection of rock-specimens will be removed to cases where it can be exhibited to much greater advantage. As the suggested improvements will necessitate an entire re-arrangement of the objects in this part of the Museum, it seems unnecessary to enter into further details as to their present position. The following objects, however, require special notice.

#### MODEL OF THE ISLE OF ARRAN.

*By Professor A. C. Ramsay, LL.D., F.R.S.*

This model is on a horizontal scale of two inches to a mile. The vertical heights are somewhat exaggerated. The best idea of the form of the more mountainous part may be obtained by bringing the eye to the level of the model at the S.E. corner. These mountains consist of granite, forming a circular mass at the north end of the island, about eight miles wide in all directions. The highest point (Goatfell) is 2,959 feet above the level of the sea, and rising directly from the shore, it looks even higher. This mass is surrounded by clay slate, chlorite slate, gneissic and other metamorphic rocks, the metamorphic action having been induced by the granite which they surround. In their turn they are overlaid by the Old Red Sandstone, on the east at Glen Sannox, and on the south between Brodick and the west coast north of Mauchrie Water. It is in great part conglomeratic, and pebbles of the underlying metamorphic rocks are contained in it, showing that they were altered before the deposition of the Old Red Sandstone.

The coal measures (lower coal measures) rest on the Old Red Sandstone at Brodick bay, and south of Glen Sannox, but between these points they rest, first on the slaty rocks, and then on the granite, showing that they lie on the old strata unconformably. They are also found about three miles off the N.E. coast of the island, lying on metamorphic slaty rocks. The limestones, which are interstratified with the sandstones and shales, contain the usual carboniferous fossils. Coal-measure plants are found in the sandstone and shales, and thin beds of coal occur near the salt pans. On the S.W., coal measures also appear in the valleys where the trap rocks have been removed by denudation. The New Red Sandstone overlies the coal measures at the Cock of Arran (N.E.), and also forms the major part of the coast of the S.E. of the island. It is doubtful, however, whether these rocks do not in reality form only a higher part of the coal measures. The major portion of the south part of the island consists of felspathic traps and greenstones of comparatively late geological date, for they have broken through the stratified rocks indiscriminately and overflowed them, so that in general it is only in the valleys that the underlying strata of coal measures, &c., have been exposed by denudation.

Sulphate of baryta is obtained in tolerably large quantities on the hill to the south of Glen Sannox, and in the bed of a small torrent originating in *Corrie na Chiodh*.

MODEL OF A PORTION OF THE ISLE OF WIGHT, by Capt. Boscawen  
Ibbetson, K.R.E.

This model represents the coast of the Isle of Wight between Sandown Bay and Whitecliff Bay. The almost vertical position of the chalk is well indicated by the layers of dark flints occurring in the upper chalk. The tertiary beds which rest on this highly inclined chalk are, in ascending order, the plastic clay or Woolwich and Reading series, the London clay, the various subdivisions of the Bagshot beds, the Headon and Osborne series, and the Bembridge beds. (See Mr. Bristow's Memoir on "The Geology of the Isle of Wight.")

PROPORTIONAL SECTION of the *Himalaya mountains*, upon the panel near Wall-case 7.

The height from the floor of the principal room of the Museum to the line on the brass plate which represents the level of the sea, which is  $27\frac{1}{2}$  feet, being considered equal to the diameter of the earth, this section shows the height of the Himalaya mountains, as compared with that diameter. The height of the most elevated portion of this range approaches to 30,000 feet. The Earth's diameter being about 8,000 miles, it follows that the greatest elevation above the sea level is less than the 1,600th part of that diameter.

Against the door on eastern side will be found a *scale of relative heights as a geological standard scale*, suggested by Mr. P. Nasmyth.

A, B, represents an arc of a circle 66 feet in diameter, representing 120 miles of the Earth's surface, at the sea level, to the scale of 1-10th of an inch to a mile, on which are represented the relative heights of—

1st. Snowdon	-	-	-	-	3,571 feet.
2nd. Vesuvius	-	-	-	-	3,800 "
3rd. Etna	-	-	-	-	10,874 "
4th. Mont Blanc	-	-	-	-	15,732 "
5th. Mount Everest, Himalaya	-	-	-	-	29,000 "
6th. The deepest mines	-	-	-	-	2,200 "
7th. The probable average of the whole Earth above the level of the sea.					

Several *geological photographs*, presented by Mr. J. J. Cole, F.R.A.S., are suspended against the panels at the southern end of the gallery.

In the south-east corner stands a *model of the salt mine of Aussee*, forming a companion to the two similar models on the principal floor, described at p. 60.

SUN AND PLANETS.—Above the door of the Mining Record Office in this gallery is placed a gilded globe, which is intended to represent the Sun. At relative distances, in comparison with the size of this sphere, there are placed, upon projecting arms from the table-cases, representations of *Mercury*, *Venus*, and of *Earth*, with her satellite the *Moon*. This arrangement is intended to familiarize the mind with the immensity of space, and the size of the masses of those planets which are nearest the great centre of the system, in which the earth is a small unit. The great size of the Sun will be conceived by looking at the earth—a globe nearly 25,000 miles in circumference, and her satellite of a correct comparative size, at the proper relative distance from her. If the centre of the Sun and Earth were coincident, the Moon circulating in her orbit at the same distance from the Earth as she now moves, would revolve within the

mass of the Sun, and leave a space beyond equal to the distance of the Moon from us, before reaching the edge of the solar disc.

*Cervus megaceros* or *Megaceros Hibernicus* (the Irish Elk).—The skull and antlers of this remarkable animal, of which numerous remains have been found in the peat bogs of Ireland, are placed above the cases at the circular end of the upper gallery. It is an extinct species of post-pleistocene age, remarkable for its size, the spreading antlers measuring in some specimens as much as 10 feet from tip to tip. It is clear that the antlers usually embedded in peat-bogs have not been shed, for they are found attached to portions of the skull, proving that the whole animal perished. The so-called Irish Elk probably belonged to the group of true stags, and not to the Elks as was at one time supposed.

#### MINING RECORD OFFICE.

This branch of the establishment owes its origin to a representation made to the Government by the British Association at the meeting of that body at Newcastle-on-Tyne in 1838.

The objects to which this office is devoted are:—

1st. *The collection, arrangement, and preservation of all plans and sections of mines and collieries, both those which are now in process of work, and such as have been or may be abandoned.*

2nd. *The collection and publication of statistical information connected with the mineral produce of the United Kingdom.*

3rd. *The collection and registration of every kind of information connected with the phenomena of our mineral formations of whatever description these may be.*

The President of the Geological Society, the Rev. Dr. Buckland, in 1841, who took an active part in the establishment of the MINING RECORD OFFICE, thus spoke of its objects:—"To the Keeper of these Records will be assigned the duty of arranging the documents which may be transmitted to him from all parts of the kingdom by any engineers, mineral surveyors, and proprietors of mines and coal works who may be willing to send them; particularly *Maps, Sections, and Underground Plans*, which will record the state of each mine when it is abandoned, for the information of those who, at a future period, may be disposed to bring it again into operation."

At the present time the MINING RECORD OFFICE contains a large collection of the Plans and Sections of abandoned and of existing mines, and a considerable amount of information connected with the mineral produce of the United Kingdom. To all parties who are specially interested in these industries, the collections of the office are opened upon application to the Keeper of Mining Records. Statistical returns of the mineral produce of these islands are published annually; these returns being indeed the only reliable information which is given to the public of a branch of British industry, the value of which, independently of building stones, amounted in 1874 to 57,839,697l.

A Catalogue of the Documents in the *Mining Record Office* has been published.

LONDON:

Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODE,  
Printers to the Queen's most Excellent Majesty.

For Her Majesty's Stationery Office.

[19445.—5000.—11/76.]

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11/76











